United States Court of Appeals

for the

District of Columbia Circuit

TRANSCRIPT OF RECORD

For hearing 11/2/56
M-F-D
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JOINT APPENDIX

IN THE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

United States Court of Appeals
For the
District of Columbia Circuit
FILED JUN 8 1956
Joseph W. Stewart
CLERK

Appeal No. 13,253

ERNEST J. SVENSON, APPELLANT,

397

vs.

ROBERT C. WATSON, Commissioner of Patents,
APPELLEE.

APPEAL FROM THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

The Scheffer Press, Inc.—ANdover 3-6850

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IN THE DISTRICT COURT OF THE UNITED STATES
For the District of Columbia

ERNEST J. SVENSON
301 South Water Street
Rockford, Illinois,
Plaintiff,
v.
ROBERT C. WATSON,
Commissioner of Patents,
Defendant.

Civil Action
No. 1770-53

COMPLAINT

Action for Issuance of a Patent (35 U.S.C. 1952 145)

The plaintiff herein, for his complaint, alleges:

1. The plaintiff, Ernest J. Svenson, is a citizen of the United States, and a resident of Rockford, in the County of Winnebago and State of Illinois.

2. The defendant, Robert C. Watson, is the Commissioner of Patents, and has an official residence in the District of Columbia.

3. This complaint is filed in accordance with the provisions of the Federal laws of the United States, as provided in 35 U.S.C. (1952) 146.

4. The plaintiff, Ernest J. Svenson, on January 31, 1946, filed an application for Letters Patent in the United States, which application is entitled "Cam Structure And Method Of Manufacture," and which was given the Serial Number 644,627.

47 5. Said application, Serial Number 644,627, filed January 31, 1946, is a continuation-in-part of application Serial Number 622,397 filed October 15, 1945, and issued as United States Letters Patent Number 2,588,430 on March 11, 1952.

6. Said application, Serial Number 644,627, filed January 31, 1946, was filed in accordance with the laws of the United States and the Rules of the Patent Office and was duly prosecuted before the tribunals of the United States Patent Office.

7. Said application, Serial Number 644,627 filed January 31, 1946, was passed upon by the Primary Examiner, who refused to allow any of the claims thereof, and who cited in his various Official actions the following patents and publications:

Hawley — 1,922,951
Vickers — 1,989,900
Rybicky — 2,247,412
Johnson — 2,259,472
Tweedale — 2,411,602
Rosen — 2,445,971
Elements of Mechanism by Schwamb, Merrill and James, 4th Edition, published by John Wiley & Sons, 1930, pp. 216-236.

8. The Primary Examiner, on February 14, 1951, finally rejected all of the claims then in the case, to-wit: Claims 7, 8, 11 to 16, and 20 to 27.

9. Subsequent to the final rejection an amendment was entered which substituted claims 28, 29, and 30 for claims 7, 8, 25 and 27, and which substituted claims 31, 32 and 33 for claims 20 to 24 and 26 for the purpose of putting them in better condition for appeal.

48 10. In a subsequent amendment claim 33 was cancelled.

11. Plaintiff thereupon appealed from the decision of the Primary Examiner to the Board of Appeals.

12. The Primary Examiner, in his statement supporting his final rejection, stated that claims 11, 12, 13 and 30 were finally rejected on the ground that they were not considered patentable over any one of the patents to Rybicky, Johnson or Rosen, especially in view of the publication "Elements of Mechanism"; that claims 14, 15 and 16 were finally rejected for lacking patentability over the patent to Johnson; that claims 28 and 29 were finally rejected as lacking patentability over the teaching of the Rybicky, Johnson or Rosen patents; that claims 31 and 32 were finally rejected on Vickers or Tweedale in view of Hawley; and claims 31 and 32 were further finally rejected as attempting to define over Vickers or Tweedale at the very point of alleged novelty, by a bare statement of function.

13. Subsequent to the hearing before the Board of Appeals, an amendatory paper was filed cancelling claims 14, 15, 16, 28 and 29.

14. The Board of Appeals in its decision rendered October 21, 1952, affirmed the ruling of the Primary Examiner, on the grounds set forth by said Primary Examiner, whereby plaintiff was refused a patent under 35 U.S.C. 63, as amended, on claims 11, 12, 13, 30, 31 and 32 set forth in Schedule A attached hereto.

49 15. Profert of a copy of the record of plaintiff's application in the United States Patent Office is hereby made.

16. Plaintiff denies that the rejection of said claims 11, 12, 13, 30, 31 and 32, set forth in Schedule A, was proper and contends that such claims should be allowed. More particularly, plaintiff believes and avers that the Board of Appeals erred in not allowing said claims 11, 12, 13, 30, 31 and 32, and erred in the application of the references and the grounds of rejection thereunder.

17. No appeal has been taken in this case to the United States Court of Customs and Patent Appeals, and this suit is filed within six months from the date of the decision of the Board of Appeals.

18. Plaintiff further states that the said invention is new and useful, and was not known or used by others in this country before his invention thereof, and not patented or described in any printed publication in this or any foreign country before his invention thereof or more than one year prior to his application for patent therefor, and not in public use or on sale in this country for more than one year prior to said application, and not patented in any foreign country by him or his legal representatives on an application filed more than twelve months prior to said application for United States patent and has not been abandoned.

50 Wherefore, plaintiff prays that this Honorable Court adjudge and decree that plaintiff is entitled, according to the law, to receive a patent for his invention specified in the aforesaid claims recited in Schedule A, and for such further relief as may be in order and required.

Ernest J. Svenson
By /s/ Moore, Olson & Trexler
Moore, Olson & Trexler
Attorneys for Plaintiff
813 National Press Building
Washington, D.C.

/s/ Roy H. Olson
Roy H. Olson
Attorney for Plaintiff
813 National Press Building
Washington, D.C.

Charles L. Sturtevant
Charles L. Sturtevant
Attorney for Plaintiff
813 National Press Building
Washington, D.C.

51 Filed April 20 1953 Harry H. Hull, Clerk

SCHEDULE A

CLAIMS

11. The method of forming a cam track for a cam structure which comprises assuming a circular base line, adding the ordinates of a sine curve progressively to the base line, and forming a cam track for the cam structure along the sine-like line thus determined.

12. The method of forming a cam track for a cam structure which comprises assuming a circular base line, adding the ordinates of a sine curve progressively to the base line, modifying the line thus computed in accordance with the shaping of a machining tool adapted to machine the cam track, forming a matrix cam surface in accordance with the modified line thus determined, and guiding the machining tool in accordance with the matrix cam surface whereby to form the cam track for the cam structure.

13. The method of forming a cam track for a cam structure which comprises assuming a circular base line, adding the ordinates of a sine curve progressively to the base line, modifying the line thus computed in accordance with the shaping of a circular machining tool, forming a matrix cam surface from the line thus determined, and guiding the machining tool in accordance with the shaping of the matrix cam surface while forming the cam track for the cam structure with the tool.

52 30. The method of making a ring-like cam structure having spaced substantially circular portions disposed at different radial distances from the center of the ring-like cam structure and joined by a cam riser surface, which method consists in laying out a sine curve with an amplitude equal to the difference in radial distances of the circular portions from the center of the ring-like cam member, dividing the lengthwise extent of the sine curve into increments corresponding to the angle subtended from the center of the ring-like cam member between adjacent ends of the circular portions, transposing the sine curve to an arcuate pattern along the subtended arc between adjacent ends of the circular portions, making a matrix cam having a control surface following the arcuate pattern, positioning a ring-like member adjacent the matrix cam with a cutting tool disposed on the inner surface of the ring-like member and controlled in its movements by the matrix cam for forming the ultimately desired cam structure along the inner surface of said ring-like member.

53 31. A cam structure for use with rotary blade pumps including translatably mounted blades and comprising a ring-like body having a substantially circular outer surface and having an internal surface including a plurality of cam tracks formed therein, each of said cam tracks being constructed and arranged to impart harmonic motion simultaneously to the translatably mounted blades when relative rotation occurs between the blades and one of the cam tracks and to cause actuation of said blades, the said cam tracks being located diametrically opposite one another causing associated blades to move in harmonic motion outwardly and inwardly, whereby to produce a balanced load on the cam structure.

32. A cam structure as claimed in claim 31, wherein the cam tracks formed in the internal surface of the ring-like body are joined by a plurality of circular surfaces connecting the said cam tracks.

54 Filed May 2 1953 Harry M. Hull, Clerk

United States District Court
For the District of Columbia

Ernest J. Svenson,
Plaintiff
v.
Robert C. Watson,
Commissioner of Patents,
Defendant

Civil Action
No. 1770-53

ANSWER TO THE COMPLAINT

To the Honorable the Judges of the United States District Court for the District of Columbia.

1, 2. The defendant admits the allegations of paragraphs 1 and 2 of the complaint.

3. He states that this action should be brought under 35 U. S. C. (1952) 145.

4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. He admits the allegations of paragraphs 4 to 15, inclusive, of the complaint.

16. He denies the allegations of paragraph 16.

55 17. He admits the allegations of paragraph 17.

18. He denies the allegations of paragraph 18.

Further Answering, he states that the plaintiff is not entitled to a patent containing any of the claims referred to in the complaint for the reasons given and in view of the references cited in the Examiner's statement and decision of the Board of Appeals in the plaintiff's application. Profert of copies of the said statement, decision and references is hereby made.

Respectfully submitted,

/s/ E. L. Reynolds
Solicitor, U. S. Patent Office,
Attorney for Defendant

May 1, 1953

I hereby certify that a copy of the foregoing Answer To The Complaint was mailed today to the attorney for the plaintiff, Mr. Roy H. Olson, 813 National Press Bldg., Washington 4, D. C.

/s/ E. L. Reynolds
Solicitor.

Excerpts from transcript of proceedings before Judge Maguire on April 5, 1955:

4 (Patent Office looseleaf reference booklet, indexed and tabbed "A" to "J", was marked and received in evidence as Defendant's Exhibit No. 1.)

* * *

(Certified file wrapper and contents of the Svenson application, marked and received in evidence as Plaintiff's Exhibit No. 1.)

* * *

11 *Harold Olson,*

called as a witness by counsel for the plaintiff and being first duly sworn, was examined and testified as follows:

Direct Examination

By Mr. Haight:

Q Will you state your name, please. A Harold Olson.

Q Where do you live? A Rockford, Illinois.

Q What is your occupation? A I am a research engineer.

Q By whom are you employed? A The John S. Barnes Corporation.

Q Does Mr. E. J. Svenson, the patent applicant here, have any connection with that corporation? A Yes, he does.

Q What is that? A He is president and general manager.

12 Q And has that corporation made pumps embodying the ideas disclosed in this application? A Yes, it has.

Q How long have you been employed by John S. Barnes Corporation? A Four years, as of next month.

Q And, prior to that, what experience have you had in engineering? A I was with the Ransburg Electro Coating Corporation, in Indianapolis, Indiana, for about 18 months, as a research and development engineer.

Previous to that, I was at school at the Illinois Institute of Technology, where I obtained a bachelor of science degree.

And I have also been employed by the Greenlee Brothers and Company, machine tool builders, at Rockford.

The Court: What field of engineering?

The Witness: In mechanical engineering.

By Mr. Haight:

Q Now I would like to have you describe to the Court the pump with which these cams are associated. You have in front of you, I believe, one of those pumps, which has had the nuts taken off the top of it.

The Court: Do you want to offer this as Plaintiff's Exhibit 2?

13 Mr. Haight: All right; we will mark the pump as Plaintiff's Exhibit 2.

(The pump was marked for identification as Plaintiff's Exhibit No. 2.)

By Mr. Haight:

Q Plaintiff's Exhibit 2 has been partially disassembled, has it? A Yes, sir.

Q And what has been done in the way of partial disassembly? A The removal of a bearing retaining nut at the outboard end of the shaft, as well as the removal of six screws, which hold the end cover to the main body of the pump.

Q Now will you take off the upper portion. A Yes, sir. As it appears here, we have here a loose cam, which is pinned into position. We have in the side flange the inlet ports which are connected to an external port, at this far side.

The rotor is mounted on this spline shaft, in such a manner that it fits within the cam. Fluid then enters from this external port, and is directed to the two ports that you can see down below.

As the pump is rotated, the blades then are forced out by a hydraulic pressure, as well as by centrifugal force. In
other words, there are connections from here back to
14 this point.

The Court: They are forced out to the cam?

The Witness: That is right. Also they have a pressure there providing a seal between the blade itself and the cam, which of course gives it something we don't want in the pump, in other words, a friction force. But it is something we have to contend with. We would like to reduce all those friction forces there; but we require a seal.

By Mr. Haight:

Q Now we are replacing these little blades. Is that correct? A That is correct.

Q Now will you explain to the Court how those blades are forced out. A First, I might say, these ports in the side flange which I have removed from the pump are connected to the ports on the end cover, which are in turn connected with discharge ports.

Q That means you have the high pressure fluid of the pump at the top, as we look at it? A That is correct.

The Court: What is the overall purpose of this pump? Where do you use it, and how do you use it, and why do you use it?

The Witness: The pump is used generally in the machine tool field, for actuation of heavy machine tools where a rapid traverse rate is required. It is also used in hydraulic presses, for elevator mechanisms, at any place in the hydraulic field where a large volume of fluid is required.

The Court: And the fluid is oil; is that it?

The Witness: Yes. Generally speaking, it is oil, although it may be some other non-petroleum base fluid.

By Mr. Haight:

Q What viscosities of oil does the pump handle? A I have had experience with fluids ranging from 60 or 70 Saybolt seconds up to 7,000 Saybolt seconds.

The Court: Wait a minute. Saybolt seconds?

The Witness: The Saybolt seconds is merely a means of determining the time it takes for a given volume of oil to flow through a specified diameter of tubing. It is a standard which is just set up arbitrarily, by a 68 or 70 SSU; as we term it, oil viscosity.

The Court: How do you spell the Saybolt?

The Witness: S-a-y-b-o-l-t. The 68 to 70 would correspond to something, just a very light type of oil, as you might use in your automobile engine during the winter time.

The Court: All right.

By Mr. Haight:

Q And what is 7,000, in terms of some substance 16 we know? A That has a viscosity such that it would be almost grease-like—syrupy, you might say. It is very heavy.

The Court: Like molasses?

The Witness: Like molasses, yes.

By Mr. Haight:

Q And is there any variation in temperatures? A They have been run from some place below freezing, on up to about 150 degrees Fahrenheit.

Q I wonder if we could remove this top bushing. And you might, on this drawing which I will have marked for identification as a plaintiff's exhibit—

(An enlarged drawing was marked for identification as Plaintiff's Exhibit No. 3.)

The Court: For the purpose of actuation of the machine by virtue of this pump, as you have indicated, the fluid gets into this pump from where?

The Witness: From a reservoir, a tank, from any supply of oil. There might be a barrel of oil standing beside the machine.

The Court: Through this aperture you have indicated?

The Witness: Yes.

The Court: And it goes out where?

The Witness: And it comes out at this point.

17 The Court: All right.

By Mr. Haight:

Q This drawing has been marked for identification as Plaintiff's Exhibit 3. I would like to ask the witness to point out on the Plaintiff's Exhibit 2 certain of the parts shown on Plaintiff's Exhibit 3. The inlet port, where is that on Plaintiff's Exhibit 3? A The inlet port, here. That is right. This view is taken looking from this point up into the pump.

Q We have this reversed, haven't we? A You are right. I am sorry; I made an error.

Q I now have the drawing oriented as the pump is; and the inlet 16— A That is right.

Q —is oriented with? A This one here.

Mr. Haight: Naturally that isn't quite lined up as it is in the pump, Your Honor.

By Mr. Haight:

Q But these ports down below, where are they in the drawing? A These.

Q As the pump rotates, can you trace the flow? The oil comes in, you said, at this point; it comes into the 18 inlet ports. A That is right.

Q And then what happens to it? A We have this rotor backwards. That is what the trouble is. The rotation of it would be in this direction, as shown, although it is upside down. From here over to here, it is picked up by the blade. In other words, the blade moves out as the rotor moves past the port. Then it is sealed at that point. And as it moves across there, the circular section, it forces the oil out this port, which connects up to this one in the end cap.

Q And then it would force it out the port corresponding to 64? A That is right.

Q On Plaintiff's Exhibit 3.

The Court: The oil is going into 16. Is that under pressure?

The Witness: No, sir. That is under vacuum.

The Court: And the pressure that results is the pressure as a result of this action here?

The Witness: That of course may vary, anything from—

The Court: But any pressure you want, you can operate through here?

The Witness: Yes, up to 1500 to 2000 pounds per square inch.

19 By Mr. Haight:

Q At what speeds are the rotors operated? A They are operated at from 900 to 1800 revolutions per minute. Generally we prefer to run them at about 1200 revolutions per minute.

The Court: Why is that?

The Witness: We find that the pump functions better. It is more efficient. We have less heating of the oil due to the churning action of the blades. And that, of course, is true in any pump.

By Mr. Haight:

Q When they are operating at that speed, say 1200 RPM, how many times are those little blades required to move in and out, in a minute or in a second? A Well, at 1200 revolutions per minute, of course each blade reciprocates twice. So we have 2400 reciprocations per minute, or 40 reciprocations per second.

Q Then on the question of the ticking on this cam surface, how many times will a blade scrape by any given point on that cam surface, in a second, operating at 1200 RPM? A Well, at 1200 RPM, that would be 20 revolutions per second. And we have 12 blades. Twelve by 20 would be 240 scraping actions per second on a given point on the cam.

Q Now can you tell us some of the problems in such a
pump, connected with the actual operation of the
20 blades and the cam? A If you will just let me list
them, I would say wear, vibration and hammering
of the blades as they contact the cam, the loss of seal
between the blades and the cam path proper.

Q Have you read the application that is here in issue? A Yes, I have.

Q Can you state generally what its object is? A To provide an improved cam structure and the means for making that structure.

Q Of course there are cam structures of a similar character and for the same ultimate purpose? Is that correct? A That is correct.

Q What is there in this particular structure that distinguishes it from others and would lead you to a conclusion that it is an improvement? A The shape of the cam path proper.

Q There is a difference in the so-called curvature of the cam part? A That is correct.

Q These blades are not new, are they? A No, sir.

Q And how do you make the differentiation between
this particular piece of apparatus here and the so-called
conventional or well-known cam parts? A First, the
21 type of motion which is imparted to the blades.

Q And what is that? A Simple harmonic motion.

Q And what is that? A Simple harmonic motion is the type of motion one finds, say, in the pendulum of a clock, or an object bouncing on the end of a spring. There is a smooth acceleration from rest through a point of maximum speed, and then a smooth deceleration. But a character of that motion, very definitely defined by the laws of physics—

Q What sort of a motion is it in the law of physics? A If you will permit me, I will quote from Seely and Ensign, "Analytical Mechanics for Engineers"—

> "A simple harmonic motion is defined as the motion of a point in a straight line such that the acceleration of the point is proportional to the distance, X, of the point from some fixed origin, O, in the line and is directed toward O. Or, expressed mathematically, A equals D^2X over DT^2 equals minus KX."

In other words, a constant times the distance from its center. The acceleration is equal to the reciprocal of a constant.

Q. And that would be more in line with your illus-
22 tration of a pendulum? A That is right.

Q Or one of those, I don't know the name of it, the apparatus the carpenter uses on occasion. A A plumb bob?

Q A plumb bob. A Yes.

Mr. Haight: I might at this time, Your Honor, ask the witness to explain simple harmonic motion and compare it with uniform acceleration and retardation. There is in the prior art the suggestion of that.

I will ask that this chart be marked for identification as Plaintiff's Exhibit 4.

(A chart was marked for identification as Plaintiff's Exhibit No. 4.)

By Mr. Haight:

Q I will ask you if you have this Plaintiff's Exhibit 4 prepared to illustrate the difference between simple harmonic motion and uniform acceleration and retardation. Is that correct? A Yes, sir.

Q Now, will you first explain the simple harmonic motion, the curve that is shown there—and I believe that is also in black. A In black; that is correct.

Q Now will you explain that, please. A Simple
23 harmonic motion, in this particular illustration, is based on the reference in the record Elements of Mechanism. In other words, there I have drawn a semicircle with a radius equal to one half of the travel. And on this chart of simple harmonic motion, I have 1.2, 4.5 and 9 units of travel during the first half. And there will be just the reverse on the second half of travel.

Q Then the sine curve itself is this black line, S-shaped? A That is correct.

Q To which I now refer.

The uniform acceleration and retardation is shown in dotted red lines; is that correct? A That is correct.

Q And will you explain how that is drawn on the chart? A In the case of uniform acceleration and retardation, I might state first that uniform acceleration is a type of motion which a body attains after it is dropped from rest. The ratio of movement during the first three increments are 1, 4 and 9.

The Court: When you use the term "increments," that means increases or increments of what?

The Witness: The increments of movement along the cam.

The Court: All right.

The Witness: In other words, these units moving
24 horizontally.

The Court: All right. Thank you.

The Witness: Then comparing it to the simple harmonic motion, it is one unit as against 1.2 units, or 4 units as against 4½ units. But you will note we will have travelled the same distance, 9 units, in each case.

By Mr. Haight:

Q. Now, did you have another chart prepared to show the resultant forces on a cam? A Yes.

Mr. Haight: We will have this marked as Plaintiff's Exhibit 5, if Your Honor please.

(Another chart was marked for identification as Plaintiff's Exhibit No. 5.)

By Mr. Haight:

Q Now I show you what has been marked for identification as Plaintiff's Exhibit 5. Will you explain that diagram to the Court. A This diagram is based on the previous exhibit, and it is based directly on the point of maximum slope at the center.

Q Where is that, the maximum? A Right here, at the center.

Q All right. A The uniformly accelerated curve
25 has a greater slope at that point, and that of course
is the maximum slope. You will note the slope increases to that point, and then drops off in each case. The uniform acceleration has the greater slope, however, of the two. And I have taken that center portion and transferred it to another chart, on which I have depicted the forces involved on the blades.

What I have selected as the basis of this chart is the force which the cam must exert against that blade to push it back to its slot. In other words, we have hydraulic pressure, we have centrifugal force, tending to force it outward. The cam path must return it. So I have selected this as the basis of the force required to return that. And using that same force on here in a vector diagram on the uniform, accelerated curve, I have a length shown here—well, let us take the force against the cam, that is acting outward from the blade, or, rather, perpendicular to the cam surface. Along the blade we have a force that is acting against and perpendicular to the cam.

Q Generally a radial force? A Yes, sir—square with the surface of the cam, rather than along the blade proper. Because, without friction, the only force that that can exert is perpendicular to its face.

The force, then, due to the uniform, accelerated curve,
perpendicular to the cam, is nearly ten per cent
26 greater than it would be if we used the harmonic
motion here. In other words, the harmonic motion is less; you would not have to push as hard against it. And also the circumferential force which acts against the

blades tends to lock them in their slots. In other words, that force is increased by more than 14 per cent.

Q That is increased by what? A The change in slope from harmonic motion to uniform acceleration and retardation.

Mr. Haight: Your Honor, I think I would like to offer just a cam, separate, as Plaintiff's Exhibit No. 6. And I will also offer in evidence Plaintiff's Exhibits 1 to 5, inclusive, previously identified.

The Court: Very well.

(A cam was marked and received in evidence as Plaintiff's Exhibit No. 6.)

(Plaintiff's Exhibits 2, 3, 4 and 5, heretofore marked for identification, are received in evidence.)

By Mr. Haight:

Q I will ask the witness if he can identify Plaintiff's Exhibit 6 as a cam made by John S. Barnes Corporation, in accordance with this invention. A Yes, it is.

Q Now could you turn to the patent drawings of
27 the application—

Mr. Haight: And that is H. I believe, in your booklet, Your Honor. Or I have a set, if Your Honor would like them.

The Court: No; I have it. Thank you.

By Mr. Haight:

Q I wish you would turn to Figures 1 and 2 of that sheet and just briefly explain how the internal cam surface on this ring is prepared. A You asked me to refer to Figures 1 and 2 and 3?

Q Well, I will ask for that sheet. A Figure 1 is generally a view of the cam, showing the cam there being denoted by the numeral 10. It also shows a portion of the rotor and the blades, as well as a portion of the matrix cam in the upper righthand corner.

The Figure 2 is an enlarged portion there of the upper righthand quadrant of the inner cam surface, I would say extending from point 22 to, well, vertically. I am sorry. That isn't a point there. That is the lower portion. But, anyway, the upper righthand quadrant.

The Court: How is it the upper righthand quadrant, in this drawing?

The Witness: Oh, I beg your pardon. It is the upper left.

By Mr. Haight:

28 Q Now will you go to Figure 2. And first I will ask you, what is the surface 22? A The surface 22 is the radial portion of that cam path.

Q There are how many degrees there in this quadrant? A There are 20 degrees.

Q And that is a portion of a wheel; is that correct? A That is correct.

The Court: May I interrupt again? 22—radial aspect of the surface of the cam.

The Witness: That is right. That is a portion of the—

The Court: Looking at it which way? You have a cam there. Let me see what you are talking about.

The Witness: This, sir, is a radius here. And this is a radius. And these two radii—

The Court: I see. In other words, a diameter drawn all the way through.

The Witness: Yes, sir.

By Mr. Haight:

Q That is, there are four arcs of circles in this cam. Is that correct? A That is correct.

Q Two of them of a smaller circle, and two of a
29 relatively larger circle? A That is correct.

Q All right. On this quadrant, show me what is the number of the relatively smaller circle. A No. 22.

Q And show me what is the number of the relatively larger circle. A Twenty-four.

Q And there are 20 degrees of each of those shown in this quadrant? A That is correct.

The Court: We will suspend for ten minutes, and resume at eleven-thirty.

(Following brief recess:)

By Mr. Haight:

Q Will you continue with Figures 3 and 2, explaining the sine curve transition between the inner portion of circle 22 and the outer portion of the circle 24. A The Figure 3 indicates a portion of a sine curve, whose height, denoted by numeral 32, is equal to the difference in radii to the line 22 and the line 24 of Figure 2.

Q Is that shown as 32a at the bottom of Figure 3? A Yes, it is. It is 32 and 32a; they have the same length. The horizontal length 34 in Figure 3 is equal in length to the arc between the points 28 and 30 of Figure 2.

Q That is between the 20-degree point and the 70-degree point? Is that correct? A That is correct.

The fact that the line 31 of Figure 3, then, is a sine curve of a known length and a known height, defines it mathematically. In other words, we can take a table of sine functions and determine the heights of that curve at any point along its base. And then taking those heights, we add those to the radius to the surface 22 of Figure 2, to get the curve which extends then from 28 to 30 on Figure 2.

If you look at the 55-degree mark, you will find a line 40 which is equal in length to the 40 marked on the 55-degree mark at Figure 3.

Q All right. Will you now explain, from Figure 1, how, if you are going to use a point cutter, you will develop your matrix cam from the determinations just made.

A Using a point cutter, the distance from the surface of the cam, that is, from the surface of the pump cam, to the surface of the matrix cam, which is at dimension 50 in Figure 1, is a constant. There is no correction needed.

Q Now, other figures of the patent, I believe 9 and 12, show the actual mechanism.

Mr. Haight: I might say, Your Honor, this machinery isn't involved here; but it might be helpful if the witness were to turn to Figures 9 and 12, which are on sheets 3 and 4 of the drawings.

31 By Mr. Haight:

Q And in Figure 9, is the cam surface for the pump shown? A Yes, it is.

Q What number? A Numeral 16.

Q And then turning to Figure 12, is that cam surface shown in Figure 12? A Yes, it is—again numeral 16.

The Court: What is 12?

Mr. Haight: Twelve is the general designation of the ring, I believe, Your Honor.

The Court: All right. Sixteen is the point.

Mr. Haight: Twelve is shown in Figure 4 as the ring itself, and 16 as the cam surface, I believe, Your Honor.

The Court: Yes.

By Mr. Haight:

Q Now, in Figure 9, the member 104—do you find that? A Yes.

Q Can you tell the Court where that 104 is? In Figure 12? It is right below the 16, on the exterior surface?

A Yes; that is right.

The Court: Yes, I see it.

32 By Mr. Haight:

Q And that matrix cam, also in Figure 9, bears what number? A Forty-eight—at least the external surface of it.

Q The external surface of it? A Yes, sir. Forty-four I guess is the cam proper.

Q And then in Figure 12, 44a is shown as the article, with 48a as the external surface of the matrix cam? A That is right.

Mr. Haight: I don't think it is necessary to go into the description of all of this equipment, Your Honor, by which this extra matrix cam can actually direct the cutting of the internal cam. Your Honor will notice in Figure 10 they have a circular cutter, which might be a grinding wheel or it might be a milling cutter, right next to Figure 9. That actually is what is shown in Figure 12, with the cutter 128, and the spindle 124.

By Mr. Haight:

Q Now, if you could turn to sheet 2, which has Figures 4 and 5 on it, and just briefly describe the adjustment made when using a circular cutter. A I think the important point to it here is the fact that the circular cutter is not cutting the cam at a point which would be determined by a radial line drawn through its center. In
other words, in this particular case the cutter is
33 shown as having its center at 146, on the line 148,
which is the 45-degree line. However, the point at which it is touching and cutting on the cam surface is on the line 154, at the point 150. It is necessary to make the correction for that displacement of the cutting point.

Q Without going through all of the mathematics of it, can you just state in a general way how that is done? A The calculations are actually based on a measurement of the angle shown as lower case "a" in Figure 5. That angle is measured; and then the distance from the center, 158—

The Court: Wait a minute. I have lost you. Where is that lower case "a"?

The Witness: The lower case "a" is down nearer the center.

The Court: Oh yes.

The Witness: That angle is measured with a protractor. And then the point 150 may be calculated mathematically from the sine function and the sine curve, basing it on that angle. In other words, we can determine the rise of the cam to that point 150. Then by the calculation of the triangle shown there, we can locate the point 146 on the 45-degree angle, and its distance from the center, 158, to solve a triangle, then, for the length B.

34 By Mr. Haight:

Q And then how is the distance from the center, 158, to the 45-degree point on the matrix cam, which is shown at 160 in Figure 4, how is the length from 160 down to the center then determined? A By an addition of the length B.

Q B is from the center? A B is from the center to the point 146.

Q Which is the center of the cutter. Is that correct? A That is correct.

The addition of that length B, plus R, which is the radius of the cutter, plus the constant—in this case called K, in Figure 4—

The Court: I don't see K.

The Witness: On the horizontal center line.

The Court: Yes, I see it.

By Mr. Haight:

Q And that K is the distance between the cam surface and a point beyond it on the matrix cam? A Yes. May I clarify that?

The Court: I see it. What do you mean by clarification?

The Witness: It may or may not be on the cam surface. You will note in Figure 5, on the line 148, that there is a definite space between the cam surface and
35 the radius; and that amount is the amount for which we must correct. Actually in determining the point K up here, you see, we add our length B, plus our length R, which brings us to this point, and then add K to it here. Admittedly it is shown as K here; but it is of necessity measured from the radius of the cutter rather than from the cam surface.

By Mr. Haight:

Q Can you illustrate that from Figure 10? I believe that is a little clearer in Figure 10, as compared with Figure 9. That is on sheet 3 of the drawings. You said you added the distance from the center of the cam ring, to the center of the cutter, that distance, to the radius of the cutter, to the constant. In Figure 10, is that the distance between the cam surface and the guide 104? A Yes.

Q On the outer surface of the matrix cam? A That is right.

Q You stated that pumps had been made embodying the cam which we have been discussing. Do you know how long they have been made? A Well, they were made before I went with the Barnes company.

Q. So they have been made more than four years? A Yes.

36 Q To your own knowledge. A Yes.

Q And have they been made in substantial numbers? A Yes.

Mr. Haight: Two of the references, if Your Honor please, are Vickers and Tweedale, both of which are assigned to Vickers. I was just going to ask the witness whether pumps having these cams have been sold in competition with Vickers pumps.

By Mr. Haight:

Q Have they? A Yes, they have.

Q And has the John S. Barnes Corporation from time to time tested its pumps embodying these cams and compared them with Vickers pumps? A Yes.

Q Did you recently make a comparison of one of these pumps having one of these cams, with a Vickers pump? A Yes.

Mr. Haight: Would you mark this as 7, please.

(Two sheets of tabulated test results were marked for identification as Plaintiff's Exhibit No. 7.)

By Mr. Haight:

Q Did you have a tabulation of results of this most 37 recent test prepared? A Yes, sir.

Mr. Moore: If Your Honor please, I think I will have to object to this examination. We were not present at the testing of these pumps, and there has been nothing shown here as to the structure of the Vickers pump.

* * * *

38 The Court: Well, let me take this for what it is worth. The objection is noted and it is in. I will take it for what it appears to be.

39 Mr. Haight: Then I will offer it.

(The two sheets of tabulated test results, heretofore marked for identification as Plaintiff's Exhibit No. 7, were received in evidence.)

Mr. Haight: That is all.

Cross Examination

By Mr. Moore:

Q Mr. Olson, are you related to Mr. Roy Olson, whom I introduced here? A No, sir; I am not.

Q You have indicated that other manufacturers manufacture centrifugal pumps of the type indicated in Plaintiff's Exhibit No. 2, have you not? A Yes, sir; I have.

Q And is there a Vickers organization making such pumps? A That is right.

Q What is the name of the organization? A Vickers, Incorporated.

Q And pumps on the market, including Vickers pumps, will include a rotor, will they not? A Yes, sir.

Q And a cam guide of some structure? A Yes, sir.

40 Q And they will include the casing and the ports and associated mechanism? A That is correct.

Q Will you refer to Figure 9 of the application drawings. That shows the cutting of the cam surface with a cutting blade, does it not? A That is correct.

Q There is a point cutting there? A That is correct.

Q And in Figure 10 the cutting is by a grinding tool; isn't that true? A That is correct.

Q The cam, the matrix cam shown in Figure 9, is designated by reference numeral 44? A Correct.

Q Whereas in Figure 10 it is indicated by reference numeral 44a? A Correct.

Q And figure 12 corresponds, does it not, to the showing of Figure 10, in that there you have a cutting by a grinding tool, 128? A That is correct.

Q In other words, the correspondence is between Figures 10 and 12, rather than between Figures 9 and 12? A Correct.

41 Q Now would you refer to this Exhibit No. 4, which is entitled "Cam Profile Diagram" and tell us whether or not the curve which is indicated in black is a sine curve. A The curve indicated in black is a sine curve.

Q And a sine curve is a graphical representation of simple harmonic motion, isn't it? A Correct.

Q And in the showing of the cam profiles in the Plaintiff's Exhibit No. 4, the curve indicated in red, indicating uniform acceleration and retardation, closely corresponds to that indicated in black indicating simple harmonic motion, does it not? A There is a variance in degree.

Q But there is a close approximation of the curves? A At the first point of intersection here, there is a variance of 20 per cent, sir—one as against 1.2.

Q But the curves do not vary widely, do they? A It is hard to answer that question with a definite yes or no, because "widely"—

The Court: They do vary?

The Witness: They do vary, yes.

By Mr. Moore:

Q They do vary, but they do not vary widely. Isn't that true? A I would say that 20 per cent is a con-
42 siderable variation.

Q They cannot be superimposed. A They cannot.

Q But when they are superimposed at mid-point, the variation is not great along the curve. Isn't that true? A The variation, as far as travel is concerned, is not great. However, the slope is different.

Mr. Moore: I have no further questions.

Mr. Haight: I wonder if I can just ask the witness one question I have overlooked.

Redirect Examination

By Mr. Haight:

Q Have you observed worn cams of Vickers pumps? A Yes.

Q And worn cams, including the cam of the application here in suit? A I have seen cams of each that have been in use.

Q Is there any difference in the type of wear that you have seen in those cams? A The wear pattern does seem to be different, yes.

Q And what is the difference in the wear pattern? A The wear of the Barnes cam appears to cover the entire length of the rise portion; whereas the wear of the Vickers cam seems to be concentrated more at the small radius portion, that is, at the point at which the cam

43 has the smallest inside diameter.

Q I might ask you about what difference that makes in the operation of the pump, after that wear takes place. A Of course, any variation in the shape of the path causes a variation in the reciprocal motion of the blades. And the wear concentrated more at one point tends to cause the blade to move very rapidly at that point and introduce a hammering action which is detrimental for two reasons. First, the blade tends to bounce back when it hammers; and second, of course that introduces additional vibration.

• • • •

44 The Court: You may withdraw any physical exhibit, because what it purports to represent and the explanation of it is in evidence.

Mr. Haight: Then we will withdraw those physical exhibits and have them at Mr. Sturtevant's office.

(Plaintiff's Exhibits 2, the pump, and 6, the cam, accordingly withdrawn.)

• • • •

PLAINTIFF'S EXHIBIT NO. 1

Excerpts from the file wrapper and contents of the Svenson Application Ser. No. 644,627 as follows:

1 This invention relates to cam structures and methods for effecting their machining and fabrication. The invention concerns particularly cams for rotary blade pumps.

It is an object of the present invention to provide an improved cam structure, of improved construction, and improved operating characteristics in cooperation with an associated cam follower element.

More specifically stated, it is an object of the invention to provide a cam structure having a more accurately defined cam surface; and a cam surface which in the particular embodiment set forth will impart simple harmonic motion to an associated rotary cam follower element.

It is a further object of the invention to provide improved means and methods for fabricating cam structures of the foregoing type, and more specifically to provide improved cutting and grinding methods and apparatus for machining the cam surface or surfaces.

A still further object of the invention is to provide improved means and methods for fabricating a cam struc-
ture for use with rotary blade pumps, and specifically
2 for use with a pump such as shown in my copending
application, Serial No. 622,397, filed October 15, 1945,
of which the present application is a continuation-in-part.

Various other objects, advantages and features of the invention will be apparent from the following specification when taken in connection with the accompanying drawings, wherein certain preferred embodiments are set forth for illustrative purposes.

In the drawings, wherein like reference numerals refer to like parts throughout:

Fig. 1 is a diagrammatic view illustrating a cam structure constructed in accordance with and embodying the principles of the invention, and illustrating more particularly the means and methods for calibrating and forming the matrix cam for producing the cam surface;

Figs. 2 and 3 are illustrating views showing various steps in the calculation of the matrix cam;

Figs. 4 and 5 are illustrative views corresponding, respectively, to Figs. 1 and 2, but more particularly showing the method of grinding the cam surface, and the method of fabricating the matrix cam used in connection with the grinding operations;

3 Fig. 6 is a partial view of a machine tool structure and tool arrangement, used in machining the cam;

Fig. 7 is a transverse sectional view of the structure of Fig. 6, along the line 7-7 thereof;

Fig. 8 is a perspective view of the work piece from which the cam is formed;

Figs. 9 and 10 are illustrative views, showing, respectively, the cutting and the grinding of the cam surfaces;

Fig. 11 is a detail perspective view showing the shaping of the follower member for the matrix cam, as used in the apparatus of Figs. 6 and 7;

Fig. 12 is a top view of the structures of Figs. 6 and 7, on an enlarged scale, and partly in section to show the construction and arrangement of the parts; and

Fig. 13 is a partial view of the structure of Fig. 12, with a cutting tool substituted for the grinding wheel thereof.

4 In the drawings the principles of the invention have been applied specifically to the manufacture of the cam structure employed in the rotary blade pump of my aforesaid companion application, Serial No. 622,397, to which the present invention in certain of its aspects has particular reference. It is to be understood, however, that the principles and features of the invention, herein-

after to be set forth, may also be applied in the fabrication of cam structures for various purposes, including cams for rotary blade pumps of a specifically different type or construction.

Referring more specifically to the drawings, in Figs. 1, 2 and 3 methods are illustrated for computing and producing the matrix cam which, as will later be described, is employed in producing the pump cam surface.

In Fig. 1 the pump cam corresponding to the annular cam structure of my aforesaid copending application is generally indicated by the numeral 10. More specifically the cam comprises a body 12 having an outer cylinder surface 14 and an inner cam surface 16 adapted for engagement by a cam follower element; the cam followers in the pump structure of said copending application comprising a plurality of blades carried by the pump rotor, as diagrammatically indicated at 18 and 20, the blades being frictionally engageable with the cam surface.

The cam surface 16 comprises a pair of circular segments 22, a pair of circular segments 24 of larger diameter than the segments 22, and four cam rise portions 26 interconnecting the segments 22 and 24 as shown. In the particular embodiment each of the circular segments has an angular extent of 40°, whereas each cam rise 26 has an angular extent of 50°. The points of demarcation between the cam surface 26 and the surfaces 22 and 24 are indicated, respectively, at 28 and 30 in Fig. 2.

As previously indicated, the cam surfaces 26 are so shaped as to impart simple harmonic reciprocatory motion to the blades 18 as they slide along the cam surface propelled at a uniform rotary speed by the rotor 20.

To effect the calculation and cutting of the cam surface 26 one quadrant of the cam may be laid out as

6 shown in Fig. 2. It will be seen that in such quadrant
the smaller circular surface 22 will extend for a dis-
tance of 20°, the rise surface 26 will extend for a distance
of 50°, and the larger circular surface 24 will extend for
the remaining 20° of the quadrant sector. To effect the
calculation of the surface 26 a sine curve 31 is laid out as
shown in Fig. 3. This sine curve is so proportioned that
its amplitude as indicated at 32 is equal to the radial
distance 32a between the inner circular cam surface 22
and the outer circular cam surface 24. The length 34 of the
sine curve, corresponding to 180° thereof, is equal to the
length circumferentially of the line 34a between point 28
and the point 30a falling on the same radial line of the
cam quadrant as the point 30, previously mentioned.

The length 34 of the sine curve is then divided into fifty
divisions, as indicated at 36, corresponding to the 50°
of the cam quadrant between the points 28 and 30. The
distance of the sine curve 31 above its base line 38 at
each divisional point is then added radially to the line
34a at the corresponding divisional point on the cam to
lay out the cam surface 26. Thus, for example, the
7 distance 40 defined by the sine curve at the 55° divi-
sional point will be equal to the distance 40 at the
same 55° divisional point between the line 34a and the
cam surface 26. By this means it will be seen that a
shaping is imparted to the cam surface 26 corresponding
to the shaping of a sine curve, but corrected to translate
the base line for the curve from a straight line to an arc
of uniform curvature, corresponding to the path of travel
of the rotor 20. By this means true simple harmonic mo-
tion will be imparted to the blades, reciprocably in re-
spect to the rotor, as they pass along the cam surface 26
between the inner circular segments 22 and the outer cir-
cular segments 24 of the cam track. By thus imparting
simple harmonic motion to the blades, or other cam fol-

lower elements which may be engaged by the cam track, a maximum smoothness of operation of the followers is insured. More specifically, the radial movement of the followers proceeds from zero at the point 28, gradually and uniformly increasing to a maximum at the half way point 42, Fig. 2, and then gradually and uniformly decreasing again reaching zero at the point 30 as the followers become engaged against the circular cam track portion or segment 24.

8 Having determined the cam track contour for the cam, the matrix for use in the cutting of the cam track is next determined. As partially shown in Fig. 1, the matrix for use in cutting the cam surface comprises an annular body 44 having an inner cylinder surface 46 and an outer cam surface 48 similar *to* ~~but~~ larger than the cam track 16 of the pump cam to be made. The cam track 48 of the matrix cam is found by adding a uniform amount or increment, as indicated at 50 to each radial cam division, the outer matrix surface 48 and the inner pump cam surface 16 thus being similar or complementary, as stated, differing only in size. After thus determining the matrix cam surface 48, the matrix cam may be accurately cut in accordance with the calculations found, for example, in a standard milling machine. As will be understood, during such operation the position of the milling cutter will be set in accordance with the calculation found, as above set forth, for each rotatable position of the matrix cam within the milling machine, whereby to machine the matrix cam surface 48 in accordance with the computations made.

9 Having formed the matrix cam, the pump cam 10 is cut therefrom as indicated in Fig. 9, and by means of apparatus as shown in Figs. 6, 7, 11, 12 and 13.

The work piece from which the pump cam is fabricated is shown in Fig. 8. The work piece may, for example, comprise a suitable forging of annular shape. Prior to the cutting of the cam track, presently to be described, the work piece is machined so as to provide a pair of outer and inner cylinder surfaces 52 and 54, of suitable dimension, bounded by radial side walls, as indicated at 56. Any auxiliary appurtenances on the cam such, for example, as the notch 58 and the hole 60, may be formed either prior to or after the machining of the cam track.

Referring to Figs. 6, 7, 11, 12 and 13, the apparatus illustrated comprises a suitable lathe structure, partially shown in Fig. 6, having a bed 61, head stock 62, a tool stock 64, and a tail stock 66 not used in the present instance. The head stock carries the usual power driven rotatable spindle 68. The tool stock 64 may be propelled axially of the spindle in a controlled manner, for example by the usual feed screw 70, as shown. The fixture 72, shown in detail in Figs. 7 and 12, is carried by the tool stock 64 and moves therewith.

The fixture comprises a base portion 74 suitably clamped to the tool stock, as by means of bolts 76, and a slide 78 shiftable transversely of the spindle axis relative to the base 74 by means of suitable ways as indicated at 80. The slide 78 is provided with a cylinder 82, Figs. 7 and 12, within which is mounted a fixed piston structure 84 secured by means of a piston rod 86 to an upstanding bracket 88 formed as a part of the fixture base 74. One end of the cylinder is open as indicated at 90, whereas the other end of the cylinder is provided with an inlet duct 92 adapted for connection with an air pressure hose line 94 leading to a suitable valve controlled air pressure source of supply. It will be seen that when air pressure is introduced into the cylinder through the duct 92, the cylinder will be urged to the right as seen in Fig. 7, tending to shift the slide 78 in respect to the fixture base 74 on the ways 80.

11 A follower member 96, the detailed shaping of which is illustrated in Fig. 11, is engageable with the matrix cam, whereby to control the movement of the slide 78 under the urging action of the air pressure. More specifically, as shown in Fig. 12, the matrix cam, as shown at 44a (similar to but specifically different from the matrix cam 44, as will be presently explained), has its internal cylindrical surface 46a formed with a rabbet or groove 98 which is engaged by a complementary groove or rabbet formed as a part of a retainer ring 100 suitably bolted to a face plate 102 connected with the lathe spindle. It will be seen that the outer cam surface 48a of the matrix cam is thus mounted in position for engagement by the pointed end 104 of the follower 96.

The follower is carried within a socket member 106 screw threaded into a laterally extending arm 108 formed as a part of the slide 78, the socket member being held in the desired angular position by suitable means such as a set screw as indicated at 110. The follower is provided with a longitudinally extending slot 112 cooperable
12 with a set screw 114 carried by the socket member,
whereby to maintain the pointed end surface 104 of the follower properly horizontal in respect to the engaged matrix cam surface.

The follower 96 is longitudinally shiftable within the socket 106 under actuation by a plug member 116 which, as shown, is screw threaded into the end of the socket member 106. The plug 116 is formed as a part of the bracket 118 having handles 120 by means of which the plug member may be rotated. A shouldered screw 122 is threaded into the end of the follower, the length of the screw being such that it is freely rotatable in respect to the plug 116 but constrained from longitudinal movement in respect thereto.

It will be seen that by reason of the connections provided the longitudinal position of the follower 96 in respect to the slide arm 108 may be adjusted, by rotation of the handles 120, the follower however being constrained from rotation by the slot and set screw arrangement 112-114.

The slide 78 is arranged to receive a rotatable spindle 124, as shown in Fig. 12, or a similarly shaped fixed bar
124a, as shown in Fig. 13, a set screw 126 being pro-
13 vided to hold the bar 124a in fixed position. When the
rotatable spindle 124 is used the set screw 126 is
retracted into inoperative position. The rotatable spindle 124 is arranged to carry a grinding wheel as indicated at 128 in Fig. 12, whereas the fixed bar 124a is arranged to carry a cutting tool as shown at 128a in Fig. 13, the cutting tool being held in position on the bar by suitable means such as set screw 130.

When the rotatable spindle 124 is employed, means is provided for driving it comprising a pulley 132, Figs. 7 and 12, a belt 134, and a motor driven pulley 136 connected to and driven by a motor 138 directly mounted upon the slide 78.

The retainer ring 100, previously described, carries an auxiliary retainer ring 140 held in place by screws 142, the auxiliary retainer ring being arranged to hold the pump cam to be machined in proper position upon the retainer ring structure. A hardened bushing 144 is press fitted into the auxiliary retainer ring and receives the outer cylinder
surface of the pump cam body. It will be seen that
14 the inner cam surface 16 of the cam is thus supported
in position to be acted upon by the cutting tool 128a
or the grinding wheel 128, as the case may be.

In operation, assuming that the fixed bar 124a has been mounted in position upon the slide 78, it will be seen that as the lathe spindle 68 is rotated, and air pressure applied through the conduit 94, such air pressure will hold the follower 96 continuously in engagement with the cam surface 44a of the matrix cam thus shifting the slide 78 in accordance with the matrix cam contours and causing the cutting tool 128 to be correspondingly laterally shifted in accordance with the desired cam contour of the pump cam to be cut. As the spindle 68 rotates and the feed screw 70 operates to effect the progressive shifting of the cutting tool parallel to the spindle axis it will be seen that the desired cam contour is cut from the pump cam body 12. The initial lateral position of the cutting tool may be accurately adjusted by means of the handles 120 which effect the initial adjustment and positioning of the follower 96 in respect to the body of the slide 78 and the tool carried thereby.

15 To effect the grinding operation the spindle 124 is substituted for the non-rotatable bar 124a, the spindle being operated by the motor 138 as will be understood.

Referring to Fig. 9, it will be seen that the end 104 of the follower and the cutting point of the tool 128a may be arranged on a common horizontal and radial line in respect to the pump and matrix cam structures. Inasmuch as point contact is provided between the follower and the matrix cam, and between the cutting tool and the cam surface to be cut, it will be seen that the contours of the matrix cam will be accurately reproduced in the cam being cut; the matrix and pump cam surfaces thus being identical except for size, as has been previously described. In the case of the grinding wheel, Fig. 10, due to the fact that the grinding wheel necessarily must be of appreciable size or diameter, the point of contact between the wheel and the cam track 16 to be formed will not remain on a radial line coincident with the point of engagement

between the follower and the matrix cam. This will perhaps be best understood by reference to Figs. 4 and 5
wherein it will be seen that, for example, when the
16 center 146 of the grinding wheel is on the 45° radial
line 148, the tangential point of contact between the wheel and the cam surface will not be at the 45° line, but at a point displaced therefrom as indicated at 150. Accordingly the development of the matrix cam surface 48a for use with the grinding wheel differs from that previously set forth in reference to the cutting tool matrix cam, and will now be described.

In developing the matrix cam for the grinding wheel, Figs. 4 and 5, a cam sector is laid out and divided as previously explained in reference to Fig. 2. The cam surfaces 22, 26 and 24 are the ultimate cam surfaces, and accordingly are laid out identically as in the case of Fig. 2. To ascertain the proper cam surface of the grinding cam matrix, determinations are made for each degree position of the grinding wheel relative to the cam surface 16. For illustrative purposes in Fig. 5 the position of the grinding wheel at 45° is shown.

The cam surfaces 22, 26 and 24 having been laid out, a circle 152 representative of the grinding wheel and having a radius R corresponding to the grinding wheel radius is
formed tangentially to the surface 26 and with its
17 center 146 on the 45° radial line 148. The point 150
at which the circle 152 and the cam surface 26 meet is thus located graphically, and graphically determines a radial line 154, in the particular instance shown being slightly less than 39°. The precise angle of the line 154 may be read and determined graphically by means of a protractor. Inasmuch as the height 32 and length 34 of the sine curve 31, Fig. 3, is known, the distance 156 of the sine curve above the base line 38 at the determined an-

gular position 154 may now be calculated mathematically from the sine curve equation of the particular curve 31.

The length of the line A between the point 150 and the cam center 158 may be ascertained mathematically by adding the known radius of the base line 34a to the distance 156. Angle b added to angle a (which has been determined) is equal to angle c which is known (45° in the particular instance illustrated). Accordingly angle b may be found mathematically. Inasmuch as the length of the lines A and R and the angle b are known, the angle d may be found according to the following trigonometric equation:

$$\text{Sine } d = \frac{A \text{ Sine } b}{R.}$$

18 Inasmuch as angles b and d are now known, angle e can be determined by the following:

$$e = 180° - d - b.$$

The length of the line B between the points 146 and 158 may now be found according to the following equation:

$$B = \frac{R \text{ Sine } e}{\text{Sine } b.}$$

Having found the length of the line B, the point 160 which determines the matrix cam surface at the 45° point may be calculated mathematically by adding $B + R + K$, where K is a fixed constant corresponding to the length 50 in Fig. 1, as previously described.

As indicated, the contour of the matrix cam surface 48a is thus calculated for each angular degree in a manner similar to the 45° illustration, it also being necessary to effect the calculations sufficiently below 20° (point 28) and above 70° (point 30) to insure proper grinding wheel contact at and beyond the ends of the cam surface 26.

19 Having thus determined the cam contour 48a of the grinding wheel cam matrix, the matrix may be

machined on a milling machine as in the case of the cutting tool cam, previously described.

It will be seen that in the foregoing illustrations for the matrix surface of the grinding wheel cam only the angle a is found graphically, the remaining values all being determined mathematically from the angle a thus determined. It has been found that the angle a may be accurately found graphically, and such small errors as may occur are inconsequential in the ultimate analysis.

By the present invention means and methods are provided for more accurately controlling and machining the cam surfaces of a cam member, whereby to accurately predetermine the path of travel of the cam followers. In the cam structure set forth, an annular cam surface is provided having characteristics of true simple harmonic motion. As will be understood, the wheel 128 may effect grinding or polishing operations, as desired.

20 It is obvious that various changes may be made in the embodiments set forth without departing from the spirit of the invention. The invention is accordingly not to be limited to the specific embodiments shown and described, but only as indicated in the following claims.

21 The invention is hereby claimed as follows:

~~1. A cam structure having a *plane* cam track formed thereon, said cam track having a predetermined portion thereof shaped to impart harmonic motion to an engaged follower element.~~

~~2. A generally circular *plane* cam structure having a circumferentially disposed cam track formed thereon, said cam track having a predetermined portion thereof shaped to impart harmonic motion to an engaged follower element.~~

~~3. A cam structure comprising a ring-like body, said~~ body having one circumferential surface thereof provided with a cam track, said cam track having a predetermined portion thereof shaped to impart harmonic motion to an engaged follower element.

4. A cam structure for use with rotary blade pumps, said cam structure comprising a ring-like body, said body having a cam track formed along one circumferential surface thereof, said cam track having a low portion, a high portion, and a portion interconnecting the low and high portions shaped to impart harmonic motion to an engaged follower element.

22 5. A cam structure for use with rotary blade pumps, said cam structure comprising a ring-like body, said body having a cam track formed along one circumferential surface thereof, said cam track being provided with a pair of diametrically disposed high portions, and a series of portions interconnecting the low and high portions, said interconnecting portions being shaped to impart harmonic motion to an engaged follower element.

6. The method of forming a cam structure which comprises forming a matrix cam with a cam surface shaped in accordance with the cam surface to be formed on the cam structure, engaging the matrix cam surface with a follower member, and guiding the path of travel of a machining element along the cam track of the cam structure in accordance with the movements of the follower member, whereby to effect the machining of the cam structure.

23 7. The method of forming a cam structure which comprises forming a matrix cam with a cam surface, said matrix cam surface being computed in ac~~cordance with the shaping of the cam surface to be~~

~~formed and a machining element~~ ~~*adapted to machine the*~~ *cam surface to be formed,* engaging the matrix cam surface with a follower member, and guiding the path of travel of the machining element along the cam track of the cam structure in accordance with the movements of the follower member, whereby to effect the machining of the cam structure.

8. The method of forming a cam structure which comprises forming a matrix cam with a cam surface, said matrix cam surface being computed in accordance with the cam surface to be formed as engaged by a circular machining element of predetermined size, engaging the matrix cam surface with a follower member, and guiding the path of travel of a circular machining element of said predetermined size along the cam track of the cam structure in accordance with the movements of the follower member, whereby to effect the machining of the cam structure.

24 9. The method of forming a generally annular cam structure having a circumferentially disposed cam track which comprises forming a generally annular matrix cam with a circumferentially disposed cam surface shaped in accordance with the cam track to be formed on the cam structure, mounting the cam surface of the matrix cam and cam track of the cam structure in concentric relation, engaging the matrix cam surface with a follower member, and guiding the path of travel of a machining element along the cam track of the cam structure in accordance with the movements of the follower member, whereby to effect the machining of the cam structure.

10. The method of forming a cam structure which comprises machining a cam track on a predetermined portion of a cam body, while forming said cam track of a shaping which imparts harmonic motion to an engaged follower ~~element.~~

25 11. The method of forming a cam track for a cam structure which comprises assuming a circular base line, adding the ordinates of a sine curve progressively to the base line, and forming a cam track for the cam structure along the sine-like line thus determined.

12. The method of forming a cam track for a cam structure which comprises assuming a circular base line, adding the ordinates of a sine curve progressively to the base line, modifying the line thus computed in accordance with the shaping of a machining tool *adapted to machine the cam track,* forming a matrix cam surface in accordance with the modified line thus determined, and guiding the machining tool in accordance with the matrix cam surface whereby to form the cam track for the cam structure.

26 13. The method of forming a cam track for a cam structure which comprises assuming a circular base line, adding the ordinates of a sine curve progressively to the base line, modifying the line thus computed in accordance with the shaping of a circular machining tool, forming a matrix cam surface from the line thus determined, and guiding the machining tool in accordance with the shaping of the matrix cam surface while forming the cam track for the cam structure with the tool.

14. An apparatus for forming a cam structure comprising D^2 support means for *said* ~~a~~ matrix cam, support means for a matrix cam follower, support means for a work piece cam member to be formed, *said work piece being mounted concentric with said matrix cam* means producing relative motion between the matrix cam and cam follower, means for maintaining the follower in engagement with the matrix cam during relative motion therebetween, support means for a machining tool, and means

for shifting the tool support and work support relative to each other in accordance with the relative movements between the follower support and matrix cam support.

27 15. An apparatus for forming a cam structure comprising D^2 support means for *said* ~~a~~ matrix cam, support means for a matrix cam follower, support means for a work piece cam member to be formed, *said work piece being mounted concentric with said matrix cam* means producing relative motion between the matrix cam and cam follower, fluid pressure means for maintaining the follower in engagement with the matrix cam during relative motion therebetween, support means for a machining tool, and means for shifting the tool support and work support relative to each other in accordance with the relative movements between the follower support and matrix cam support.

16. An apparatus for forming a cam structure comprising D^2 support means for *said* ~~a~~ matrix cam, support means for a matrix cam follower, support means for a work piece cam member to be formed, *said work piece being mounted concentric with said matrix cam* means for rotating the matrix cam and the work piece cam as a unit, means for maintaining the follower in engagement with the matrix cam during rotation thereof, support means for a machining tool, and means for shifting the tool support in accordance with the movements of the follower support.

~~28 17. Cam structure and methods and apparatus therefor, substantially as shown and described.~~

* * * *

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Fig. 1.

Fig. 2.

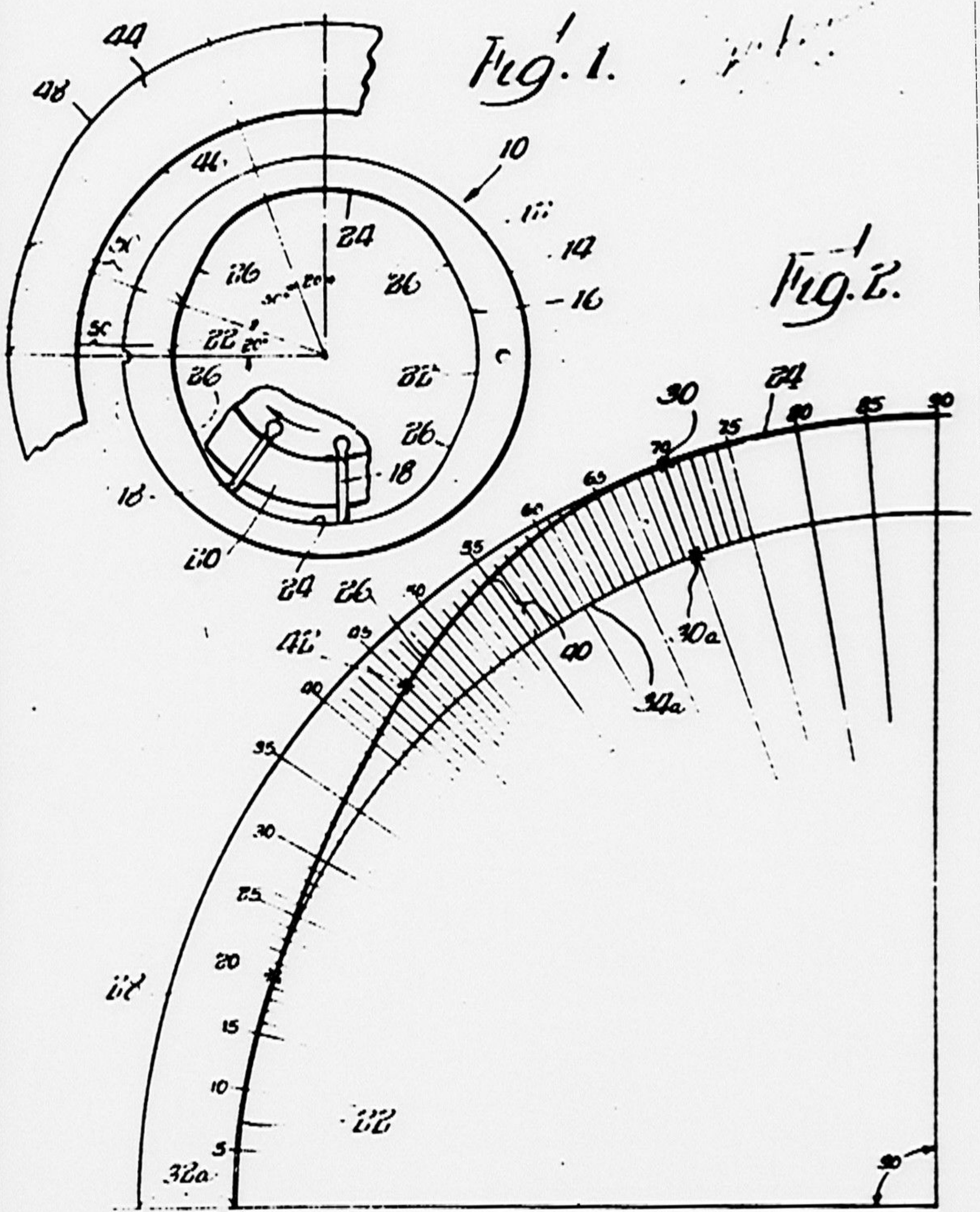
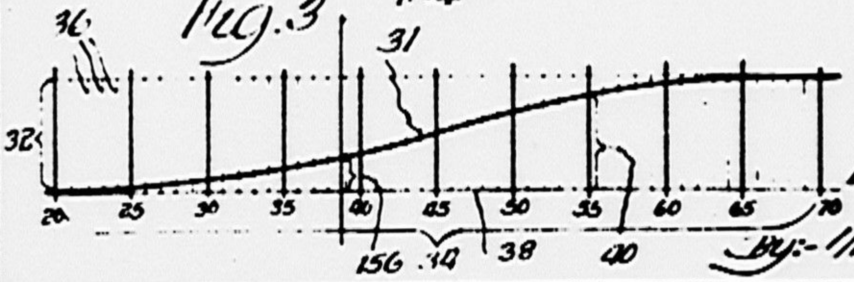


Fig. 3



Inventor
Ernest J. Swenson

By:- Moore, Olson & Trexler
Attys.

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Fig. 4.

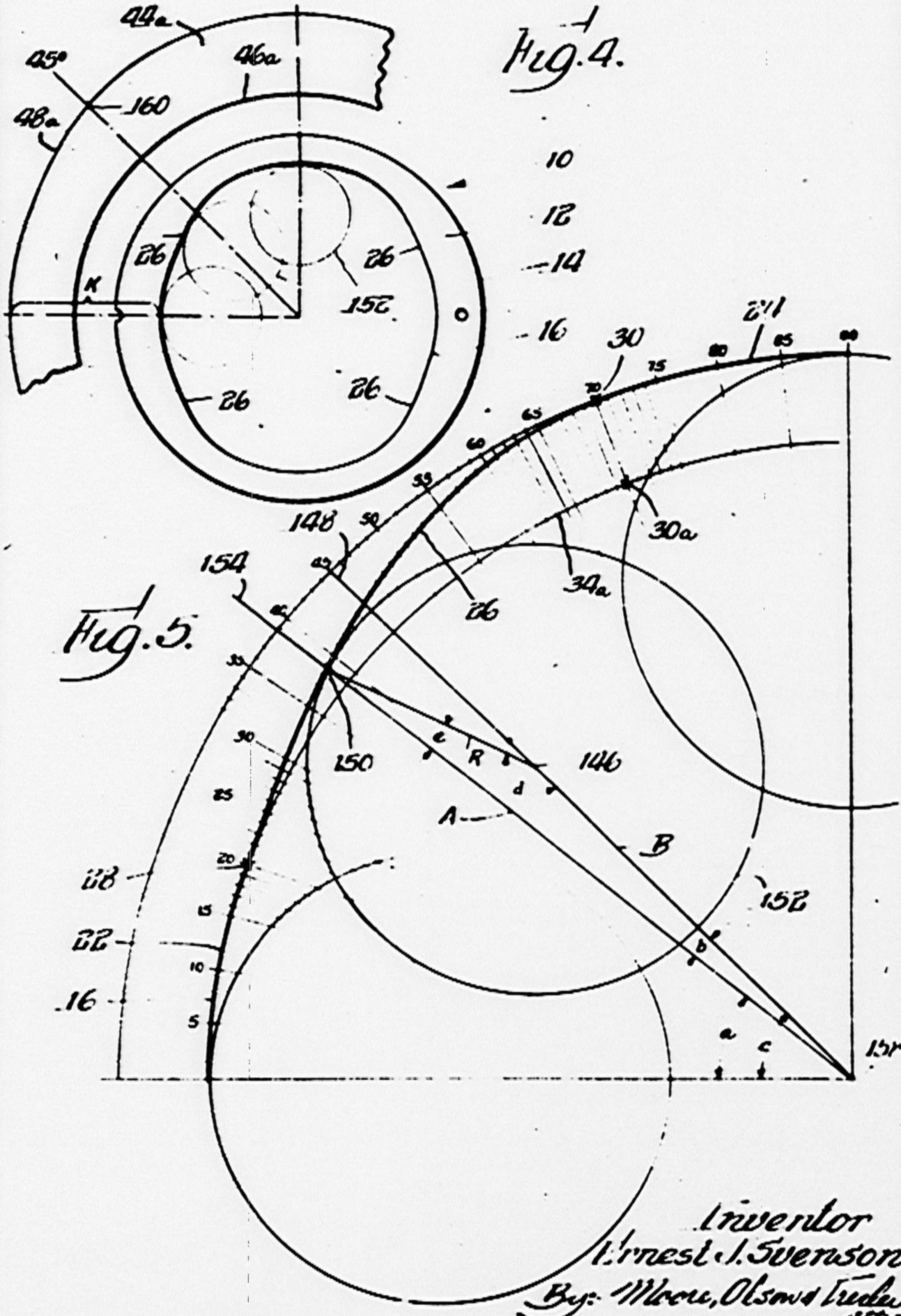

Fig. 5.

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Inventor
Ernest J. Svenson
By: Moore, Olson & Trexler
attys

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Fig. 6.

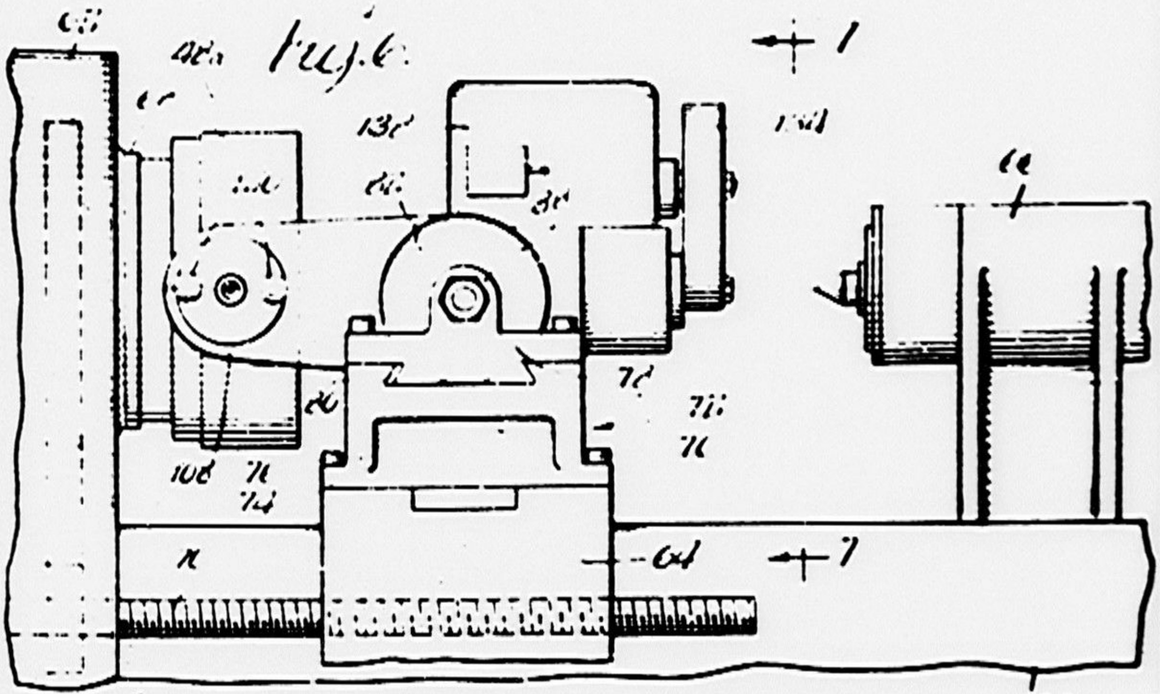


Fig. 7.

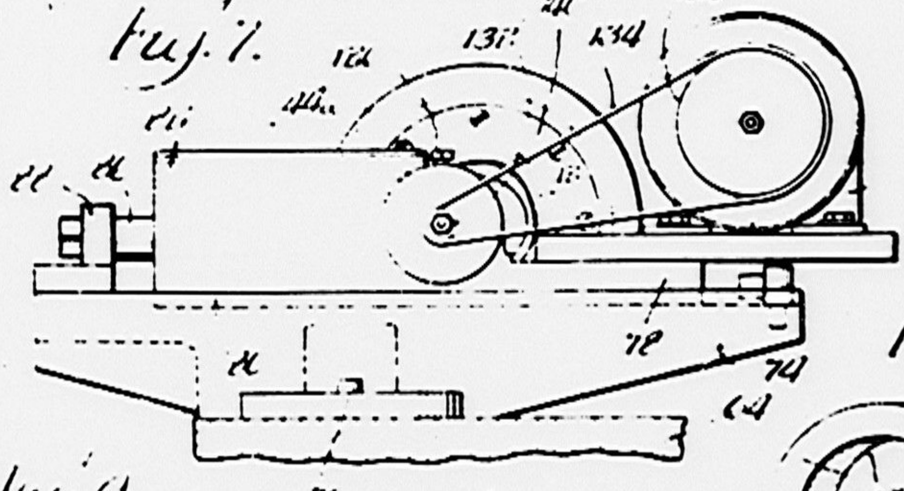


Fig. 8.

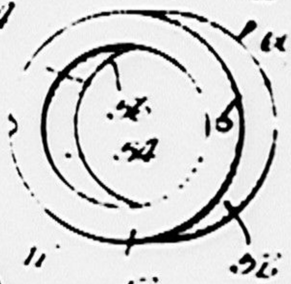


Fig. 9.

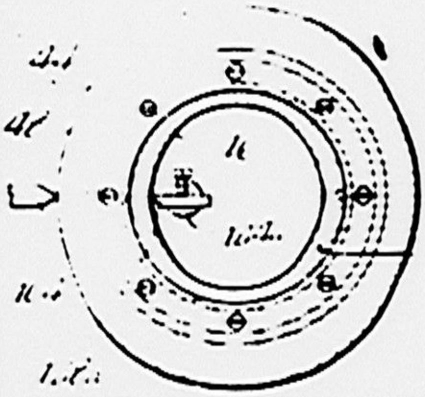
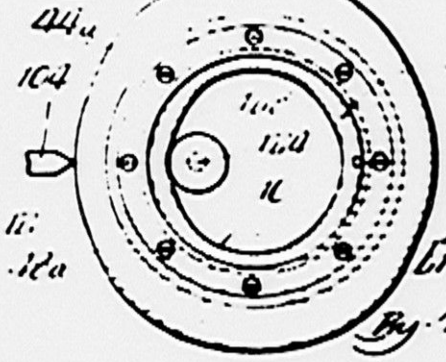


Fig. 10.



Inventor
Ernest J. Swenson
By Moore, Olson [illegible]
Attys

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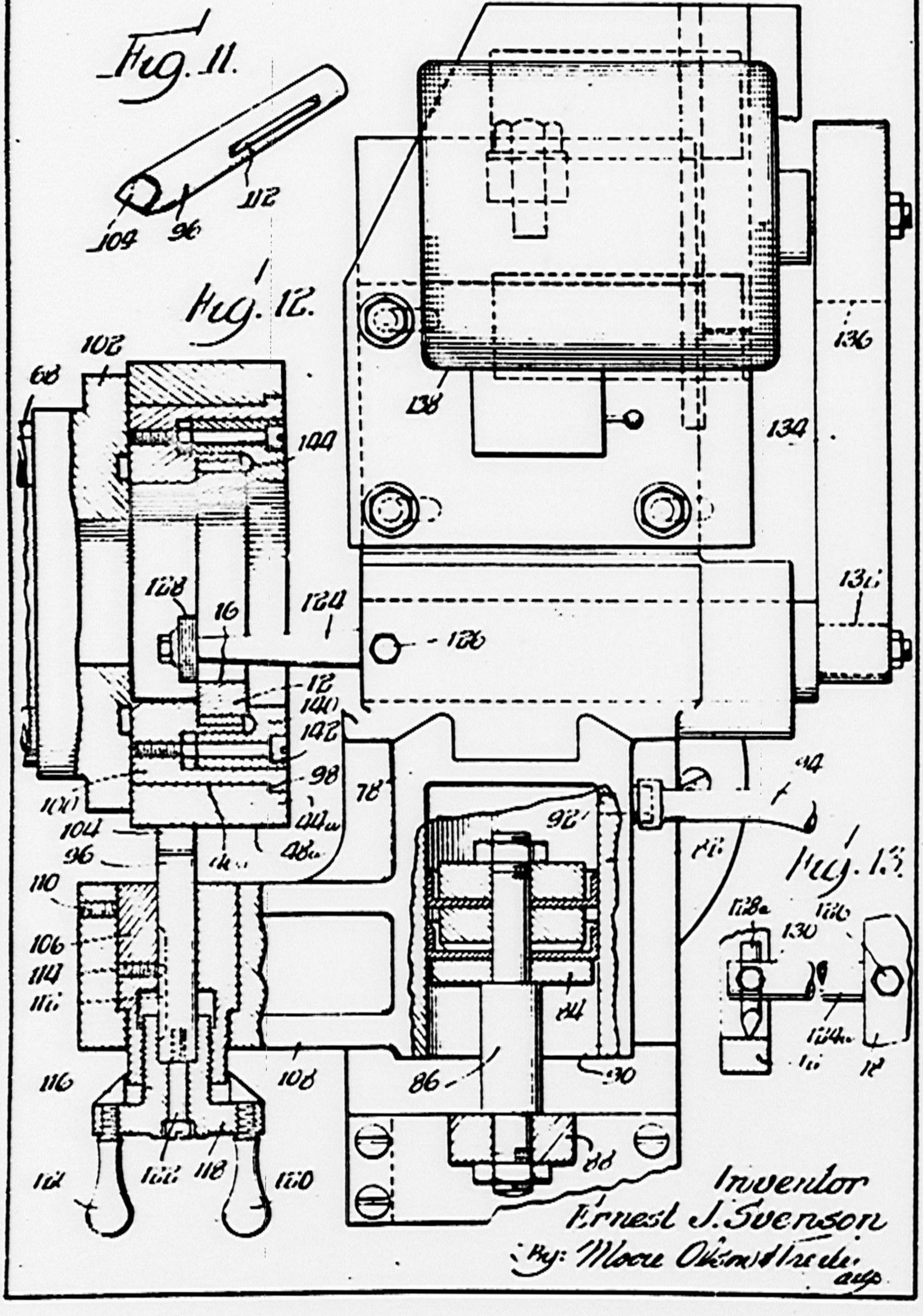
Fig. 11.

Fig. 12.



Inventor
Ernest J. Svenson
By: Moore Olson & Trexler
attys

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101 Letterhead of

DEPARTMENT OF COMMERCE
United States Patent Office
Washington

In re application of
Ernest J. Svenson
Ser. No. 644,627
Filed January 31, 1946
For Cam Structure and Method
of Manufacture

Appeal No. 29,022
Before the
Board of Appeals

Moore, Olson & Trexler for Appellant.

(Stamp: Mailed Dec 13 1951
Patent Examining Division .... 12)

EXAMINER'S STATEMENT

Applicant has appealed from the final rejection of claims 11-16, 28-32. No claims have been allowed.

The appealed claims 11-13 appear in the brief Paper #13 filed October 13, 1951 whereas claims 14-16 as amended and 28-32, admitted for purpose of appeal, appear below.

14. An apparatus for forming a cam structure comprising a matrix cam having a cam surface determined and constructed in accordance with the surface of the cam structure to be formed and also according to the shape and size of a machining tool which forms the surface of the cam structure to be formed support means for said matrix cam, support means for a matrix cam follower, support means

for a work piece cam member to be formed, said work piece being mounted concentric with said matrix cam means producing relative motion between the matrix cam and cam follower, means for maintaining the follower in engagement with the matrix cam during relative motion therebetween, support means for a machining tool, and means for shifting the tool support and work support relative to each other in accordance with the relative movements between the follower support and matrix cam support.

15. An apparatus for forming a cam structure comprising a matrix cam having a cam surface determined and constructed in accordance with the surface of the cam structure to be formed and also according to the shape and size of a machining tool which forms the surface of the cam structure to be formed support means for said matrix cam, support means for a matrix cam follower, support means for a work piece cam member to be formed, said work piece being mounted concentric with said matrix cam means producing relative motion between the matrix cam and the cam follower, fluid pressure means for maintaining the follower in engagement with the matrix cam during relative motion therebetween, support means for a machining tool, and means for shifting the tool support
102 and work support relative to each other in accordance with the relative movements between the follower support and matrix cam support.

16. An apparatus for forming a cam structure comprising a matrix cam having a cam surface determined and constructed in accordance with the surface of the cam structure to be formed and also according to the shape and size of a machining tool which forms the surface of the cam structure to be formed support means for said matrix cam, support means for a matrix cam follower, support means for a work piece cam member to be formed, said

work piece being mounted concentric with said matrix cam means for rotating the matrix cam and the work piece cam as a unit, means for maintaining the follower in engagement with the matrix cam during rotation thereof, support means for a machining tool, and means for shifting the tool support in accordance with the movements of the follower support.

28. The method of forming a cam structure which comprises forming a matrix cam having a cam surface determined and constructed according to the ultimate shape of the surface of the cam structure to be formed and also according to the shape and size of the machining tool which forms the surface of the cam structure to be formed; engaging the matrix cam with a follower member, and positively guiding the machining tool in its path of travel relative to the surface of the cam structure in accordance with movements of the follower member, whereby to effect machining of the cam structure to produce a cam surface of predetermined exact shape.

29. The method of forming a cam structure which comprises forming a matrix cam having a cam surface determined and constructed according to the ultimate shape of the surface of the cam structure to be formed and also according to the size of a circular machining tool which forms the surface of the cam structure to be formed; engaging the matrix cam with a follower member, and positively guiding the machining tool in its path of travel relative to the surface of the cam structure in accordance with movements of the follower member, whereby to effect machining of the cam structure to produce a cam surface of predetermined exact shape.

30. The method of making a ring-like cam structure having spaced substantially circular portions disposed at different radial distances from the center of the ring-like

cam structure and joined by a cam riser surface, which method consists in laying out a sine curve with an amplitude equal to the difference in radial distances of the circular portions from the center of the ring-like cam member, dividing the lengthwise extent of the sine curve into increments corresponding to the angle subtended from the center of the ring-like cam member between adjacent ends of the circular portions, transposing the sine curve to adjacent ends of the circular portions, making a matrix
103 cam having a control surface following the arcuate
pattern, positioning a ring-like member adjacent the matrix cam with a cutting tool disposed on the inner surface of the ring-like member and controlled in its movements by the matrix cam for forming the ultimately desired cam structure along the inner surface of said ring-like member.

31. A cam structure for use with rotary blade pumps including translatably mounted blades and comprising a ring-like body having a substantially circular outer surface and having an internal surface including a plurality of cam tracks formed therein, each of said cam tracks being constructed and arranged to impart harmonic motion simultaneously to the translatably mounted blades when relative rotation occurs between the blades and one of the cam tracks and to cause actuation of said blades, the said cam tracks being located diametrically opposite one another causing associated blades to move in harmonic motion outwardly and inwardly, whereby to produce a balanced load on the cam structure.

32. A cam structure as claimed in claim 31, wherein the cam tracks formed in the internal surface of the ring-like body are joined by a plurality of circular surfaces connecting the said cam tracks.

The references relied upon are:—

Rybicky	2,247,412	July 1, 1941
Johnson	2,259,472	Oct. 21, 1941
Rosen	2,445,971	July 27, 1948

"Elements of Mechanism" by Schwamb, Merrill and James, 4th Ed., 1930, published by John Wiley & Sons, pp. 216-236

Vickers	1,989,900	Feb. 5, 1935
Hawley	1,922,951	Aug. 15, 1933
Tweedale	2,411,602	Nov. 26, 1946

Applicant's device is adequately described in the brief.

THE RYBICKY DEVICE

The patent to Rybicky 2,247,412 discloses a machine for grinding cams in which the cam 5 to be ground is mounted on a spindle 3 which is rotated through suitable gearing by a motor 8. A spindle 2 is driven synchronously with the work spindle 3 by suitable gearing by motor 8. The spindle 2 carries a pattern cam 4 which is engaged by a roller follower 17 carried by a reciprocable tool supporting member 16. A grinding wheel 5′ is driven by a motor 20 which is mounted on the supporting member 16 for adjustment to and from the work and in a direction at right angles to the work axis. The tool 5′ may be engaged
104 in a groove in the work 5 and the shape thereof controlled by the pattern cam 4 as the work and the pattern cam rotate due to the driving motor 8.

THE JOHNSON DEVICE

The patent to Johnson 2,259,472 relates to a machine for milling cams (Figs. 1, 2, 3, 4 and 9). The work 14 to be formed is mounted on a rotary fixture formed with a pattern cam edge 19. This fixture is carried by a table 2 by a saddle 4 mounted on the knee 6 of the milling machine. The table 2 is moved by rotation of a lead screw 11.

A milling tool 3, driven by suitable gearing by a motor 13 is mounted on the column 1 of the machine.

A pattern tracer 25 is carried by an arm 21 which is mounted on the fixed column 1 of the machine. The tracer 25 engages the pattern cam 19 on the work holding fixture and the movement of the tracer by the pattern controls a servo mechanism actuated in response to air flow from a jet 22 which is varied by movement of the tracer element 25. The variation in air flow from the jet actuates a valve mechanism which controls admission of fluid to a cylinder 38 having a piston 37 which is connected through gearing to the lead screw 11 which moves the work carrying table 2. The work carrying table is caused to move under the control of the tracer in such a manner that the desired contour is cut on the work 14 by the tool 3.

A modification illustrated by Figures 7 and 8 shows the pattern tracing and control mechanism adapted to a lathe in which the position of the tool relative to the axis of rotation of the work is varied to cut the desired contour on the work.

105 THE ROSEN DEVICE.

The patent to Rosen 2,445,971 discloses a machine for cam grinding in which the work 31D and a pattern cam 30A are mounted on a reciprocable table 20. The work and pattern are carried by rotatable tables and are caused to rotate in unison. A pattern follower 50 and a grinding tool 41D are carried by the frame of the machine. The table 20 is biased by means of cylinder and piston 15 in such a manner as to keep the follower 50 in contact with the pattern 30A. As the pattern and work are rotated the table is caused to shift in accordance with the shape of the pattern.

THE VICKERS DEVICE

The Vickers device relates to a vane type pump in which the rotor 2 carries the vanes 4 which vanes are acted upon by the internal cam surface of cam member 5. Hence as the rotor rotates the blades move radially in and out in their pumping action from inlet port 34 to outlet port 33 through working chambers 6 and 7. The operation is the same as that of the applicant's device.

THE TWEEDALE DEVICE

The Tweedale device is a vane pump in which rotor 32 carries vanes 34 which vanes are acted upon by the internal cam surface of element 36. As the rotor rotates the vanes move radially in and out while pumping fluid from inlets ports 44 to outlet ports 46. The action is the same as that of the applicant's device.

THE HAWLEY DEVICE

The Hawley device has rotor 12 which carries vanes 18 which in turn are caused to move radially by the camming action of the peripheral wall of chamber 2. This
106 wall is designed to give a desired movement radially to the vanes as they rotate past the wall pumping fluid from inlet port 25 to outlet port 26. The action is the same as applicant intends his device to be. Hawley mentions variation of the cam surface to obtain desired characteristics. His surface is made up of two arcuate portions A & B diametrically opposed and two varying curved portions blending the arcuate portions, they also being diametrically opposed.

THE REJECTIONS

Claims 11, 12, 13 and 30 are not considered to be patentable over any one of the patents to Rybicky, Johnson or Rosen especially in view of the publication "Elements of Mechanism". These claims differ from claims 28 and 29 in setting forth a particular procedure for forming the so-called matrix cam. This procedure is considered to be taught by the publication on pages 217, 218 and 219 with particular reference to Figures 274 and 276. Figure 276 shows in particular the development of a cam having simple harmonic motion and it is well known that a sine curve will give such a motion. As a matter of fact, the sine or cosine curve is the only curve which will produce harmonic motion in a cam and point follower system. Figures 278 and 280 of the publication together with the related text material teach the modification in shape of the cam necessary when a circular follower is substituted for a point follower.

Insofar as claims 11, 12, 13 and 30 are concerned it appears that applicant has done nothing but apply well known principles of mechanism to the design of a pattern to be used in an old and well known manner as shown by the Rybicky, Johnson or Rosen patents.

107 Claims 14, 15 and 16, which have been amended for purposes of appeal, are not considered to define anything patentable over the patent to Johnson. The matrix cam set forth in the claims is not believed to define structurally over the pattern 19 shown by the patent. The statement in the claims relating to the shape and relationship of the pattern cam and the work and the tool seem to define only a relationship which must necessarily be true of the same elements of the patent. It seems to be well known that the shape and size of the follower, the tool, the pattern and the work are interrelated and that modifications of the shape of the pattern must be made to compensate for differences in size between the tool and the follower. Example 59 appearing on page 221 of the

publication "Elements of Mechanism" discusses this problem and teaches one solution thereto.

Referring to claim 15, the matrix cam 19 and the work 14 are mounted concentrically on the fixture 15 which is driven in rotation in a suitable manner. This rotation provides a relative movement between the follower 25, mounted on fixed support 21 and the pattern cam 19. Relative movement under the control of the tracer 25 is produced by the fluid motor 37 acting through the lead screw 11. This mechanism also serves to maintain the tracer and the pattern in engagement together with the spring 26.

Claim 16 contains the limitation that the tool support be shifted in accordance witih the movement of the follower support. Such an arrangement is considered to be a matter of choice and is also shown by the modification of Figures 8 and 9 of the Johnson patent.

108 Claims 28, 29 and 30 have been admitted for purposes of appeal in place of finally rejected claims 7, 8, 25 and 27.

Claims 28 and 29 are not considered to be patentable over the teaching of the Rybicky, Johnson or Rosen patents. Each of these patents teaches the procedure of engaging a pattern cam with a follower and controlling the relative movement between the tool and the work by the relative movement of the follower and pattern. As pointed out above, the relationship of size and shape of the pattern, follower, tool and work set forth in the claims appears to necessarily obtain in the patent disclosures. However, it is well known, as shown by the publication "Elements of Mechanism" that cams must be compensated in the manner required by the claims. The prior art patents show that it is well known to move either the tool or the work and the follower or the pattern. The selection of one or the other of the tool or work or the pattern or follower for movement is considered to be a matter of choice which leads to no new or unobvious result not taught by the prior art.

Claims 31 and 32 are rejected on Vickers or Tweedale
in view of Hawley. The Vickers and Tweedale pumps are
very similar to that of the applicant in that each has a
cam like element upon which the blades ride. Each cam,
like that of applicant, is symmetrical in form and thereby
is made up of "a plurality of cam tracks" in the identical
sense that the applicant uses such language. Vickers in
the concluding sentence on page 1 and in the opening
sentences of page 2 describes his cam as having an
circular outer form and having an inner surface of "more
of an elliptical shape". He further describes the inner
surface as having opposed concentric portions at its
109 co-ordinate axes with the curvature therebetween be-
ing gradual so that the surfaces merge into one an-
other. The Hawley pump has an integral cam guide with
what may be called a single can surface as distinguished
from applicant's plural cam surfaces. However, Hawley
expressly states (page 2, lines 79-90) that he designs his
cam surface to cause his vanes to have a uniformly
accelerated and retarded motion. Hawley expressly states
that he uses a curve that is "obtained from a develop-
ment of a sine curve". While the curves broadly described
in the basic references would appear to be the same as
that of the applicant, the Hawley disclosure eliminates
any doubt that persons skilled in the art were aware that
a developed sine curve is the type of curve that will
effect the desired performance. Hawley makes it clear,
at least that no invention would be involved in designing
the cam surfaces of Vickers or Tweedale as sine curves

followed by circular arcs to thereby give the harmonic motion called for by these claims. Furthermore, it is the opinion of the examiner that the mere shaping of a cam is purely a matter of kinematic design. Standing alone —outside of its combination—a cam surface is a meaningless thing. The time when a cam surface becomes significant is when it cooperates with some particular other mechanism in a manner to attain some particular result from the combination. In this case, the shape of the cam per se is being defined.

Claims 31 and 32 are further rejected as attempting to
define over Vickers or Tweedale at the very point of
alleged novelty, by a bare statement of function. Both
110 of these references show curved surfaces merging
into concentric or circular surfaces. Claim 31 merely
states that the curved surfaces are designed "to impart
harmonic motion". Thus at the very point in issue, at the
very point in question as to what these references disclose, as indicated above, the applicant uses at best merely conveniently functional language. No specific curve is defined either structurally or by specific mathematical formula, assuming merely for the sake of the argument that applicant's curve may be different.

/s/ S. Sintman,
Examiner

Moore, Olson & Trexler
135 South La Salle St.
Chicago 3, Illinois

* * *

116 Mailed October 21, 1952

U. S. Patent Office Board Of Appeals

Appeal No. 29,022

Hearing:
September 18, 1952

IN THE UNITED STATES PATENT OFFICE

Before The Board Of Appeals

Ex parte Ernest J. Svenson

Application for Patent filed January 31, 1946. Serial No. 644,627. Cam Structure and Method of Manufacture.

Moore, Olson & Trexler for appellant.

This is an appeal from the final rejection of claims 7, 8, 11 to 16, 20 to 24, 25, 26, and 27. No claims have been allowed. Subsequent to the final rejection an amendment was entered which substituted claims 28, 29, and 30 for claims 7, 8, 25, and 27 and substituted claims 31, 32, and 33 for claims 20 to 24 and 26 for the purpose of appeal. An amendment was then filed which canceled claim 33. On September 30, 1952, subsequent to the hearing in this case, an amendatory paper was filed cancelling claims 14, 15, 16, 28, and 29, and the appeal will be dismissed as to these claims. The claims before us for consideration are claims 11, 12, 13, 30, 31, and 32.

117 Claims 13 and 31 are representative and read as follows:

13. The method of forming a cam track for a cam structure which comprises assuming a circular base line,

adding the ordinates of a sine curve progressively to the base line, modifying the line thus computed in accordance with the shaping of a circular machining tool, forming a matrix cam surface from the line thus determined, and guiding the machining tool in accordance with the shaping of the matrix cam surface while forming the cam track for the cam structure with the tool.

31. A cam structure for use in controlling and actuating follower elements in a rotary pumping means, and comprising a ring-like body having a substantially circular outer surface and having an internal surface including a plurality of cam tracks formed therein, each of said cam tracks being constructed and arranged to impart harmonic motion simultaneously to a plurality of follower elements when relative rotation occurs between the follower elements and one of the cam tracks and to cause actuation of said follower elements, the said cam tracks being located diametrically opposite one another causing associated follower elements to move in harmonic motion outwardly and inwardly, whereby to produce a balanced load on the cam structure.

The references relied upon are:

Hawley,	1,922,951,	Aug. 15, 1933,
Vickers,	1,989,900,	Feb. 5, 1935,
Rybicky,	2,247,412,	July 1, 1941,
Johnson,	2,259,472,	Oct. 21, 1941,
Tweedale,	2,411,602,	Nov. 26, 1946,
Rosen,	2,445,971,	July 27, 1948,

"Elements of Mechanism" by Schwamb, Merrill and James, 4th Ed., 1930, published by John Wiley & Sons, pages 216-236.

The claimed subject matter relates to a cam structure, for use with rotary blade pumps, and a method of making the cam. Figure 1 of the drawing shows diagrammatically

the ring like construction of the cam (10), the pump rotor 20, carrying blades 18 which engage the cam surface 16, and the annular matrix cam 44 having a rotor surface 48, similar to but larger than the inner surface of the pump cam surface. This inner cam surface 16 includes
118 concentric circular portions of different diameter and
connecting portions 26 which are so shaped that simple harmonic motion will be imparted to the pump blades reciprocably in respect to the rotor as they pass along the cam surface. In the production of the cam the matrix is made first, corresponding to the desired conformation, and then the pump cam is machined, the cutting means used, being controlled in movement by the matrix cam. Appellant claims that by imparting simple harmonic motion to the blades of the pump a smoothness of operation is obtained. Further details of the cam structure and the method of its production are described in the brief to which reference is made. The Examiner has described pertinent parts of the references that have been relied upon and we see no need of repeating the descriptions here.

Claims 11, 12, 13, and 30 are directed to the method of making the cam track or surface. They recite the procedure, including the laying out of the cam curve, followed in forming the so-called matrix cam. The Examiner has rejected these claims as unpatentable over any one of the patents to Rybicky, Johnson, or Rosen, especially in view of the publication, "Elements of Mechanism". It is his view that the procedure recited in the claims is taught by the publication, particularly with reference to Figures 274 and 276 on pages 217, 218 and 219. He points out that Figure 276 shows the development of a cam having simple harmonic motion and that it is well known that a sine curve will give such a motion. He

points out that Figures 278 and 280 of the publication, taken with the related text material, teach the modi-
119 fication and shape of the cam necessary when a circular follower is substituted for a point follower. The Examiner concludes with respect to this group of claims that appellant has merely applied well known principles of mechanism to the design of a pattern, to be used in an old and well known manner, as shown by the Rybicky, Johnson, or Rosen patents.

We think the Examiner's rejection of these claims was proper, notwithstanding appellant's contention that the particular method of forming the cam track structure is not suggested in the Elements of Mechanism publication. In respect to the steps of laying out the curve construction of the arcuate pattern along the arc between adjacent ends of the circular portions, as is more specifically defined in claim 30, we think this operation involves at most the adapting and adjusting in an obvious manner of the sine curve, shown in Figure 276 of the publication, to conform to a particular motion controlling situation where smooth transition between circular portions of a cam must be had. Hawley and Vickers present such a cam arrangement, the latter stating, "the curvature of the intermediate portions between the concentric surface just described is gradual and merges with said concentric surfaces with the result that the movement of the vanes 4 takes place as a gradual outward and inward movement—." Page 2, lines 7 to 14, referring to Figure 8. We see nothing of patentable merit in the inclusion in the claims of the formation of a matrix cam and the controlling of the cutting of the desired cam by means thereof. It does not seem to be seriously contended that this procedure differs from
120 that shown to be old in Rybicky, Johnson and Rosen.

Claims 12 and 13 include the broadly stated steps of modifying the computed cam line in accordance with the shaping of a machining tool or of a circular machining tool. We agree with the Examiner that this concept is not a patentable one in view of the teaching of the publication on pages 220, 221. While the reference is concerned with a cam and follower, we do not attach patentable significance to the following of this teaching in use of a point and round cutting tool. The principle involved is the same in either case. The rejection of claims 11, 12, 13, and 30 will be sustained.

Claims 31 and 32 have been rejected on Vickers or Tweedale in view of Hawley. These claims are directed to appellant's ring-like cam structure. The Examiner points out the evident similarity between appellant's cam and that of the two references and relies particularly upon the disclosure of Hawley, especially the passage contained on page 2, lines 79 to 90. The Examiner concludes that Hawley makes it clear that no invention would be involved in designing the cam surface of Vickers or Tweedale as sine curves followed by circular arcs to thereby give the harmonic motion called for by these claims. Appellant's principal contention is that there is nothing in Hawley to suggest imparting harmonic motion to the blades. We are not in agreement with this contention. While Hawley states that the peripheral wall of the pump chamber connecting the two concentric arcs A and B may be constructed with uniformly arcuate curves,
he indicates that alternately, "some other forms of
121 curves closely approximating this curve such as ob-
tained from a development of a sine curve" may be used. Page 2, lines 83-85. We think claims 31 and 32 fail to avoid the clear teaching of Hawley that a development of a sine curve may be used for the transition cam, which must result in harmonic motion notwithstanding the references to curves producing uniformly accelerated and retardation radial motion. This rejection is sustained.

Claims 31 and 32 were also rejected as defining over Vickers or Tweedale at the very point of alleged novelty by a bare statement of function. This no doubt has reference to the limitation in claim 31 with respect to the cam tracks "being constructed and arranged to impart harmonic motion simultaneously to the translatedly mounted blades." Appellant contends that the limitation in question is a definite statement of structure and not one of function and is in fact a proper way of defining a point of novelty. We are unable to agree with appellant in this contention. The definition of the cam tracks insofar as they may be said to distinguish from those disclosed in Vickers and Tweedale is merely one of desired result. We find no structural description of the tracks not present in the references. To merely assert in the claims that the desired effect will be produced as the vanes move along the track is to fail to include the structure by which the claims must be measured. We agree with the Examiner that this is not a patentable distinction under the rule of *General Electric* v. *Wabash Appliance Corp. et al,* 304 US 364; 1938 CD 813, cited in the final rejection. We will sustain this rejection.

122 We have carefully considered the arguments in the briefs as well as those presented at the hearing but we are not convinced that there was error in the Examiner's decision.

The appeal is dismissed as to claims 14, 15, 16, 28 and 29.

The decision of the Primary Examiner is affirmed.

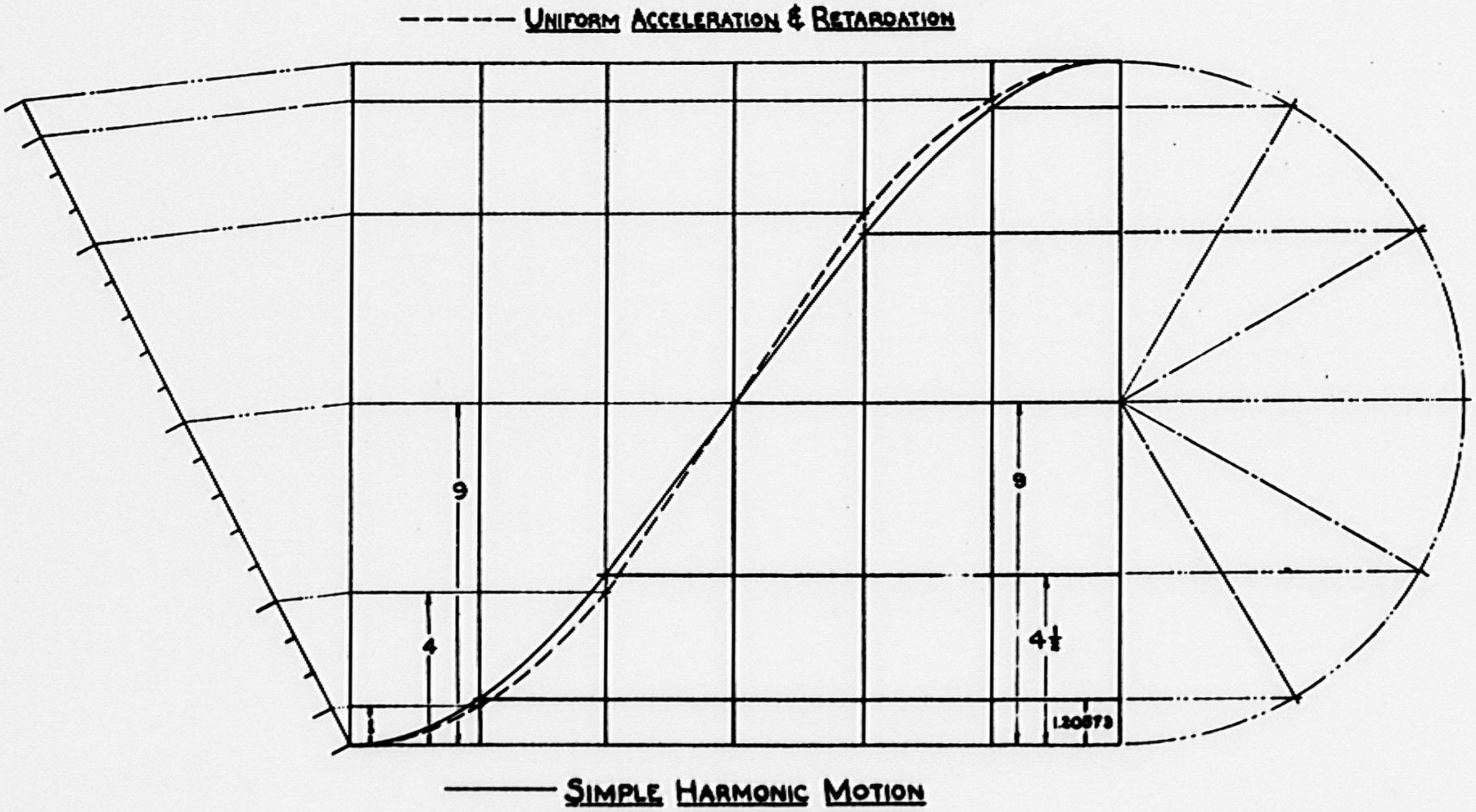
/s/ A. W. Crocker, Examiner-in-Chief /s/ M. W. Tucker, Examiner-in-Chief (Acting) /s/ J. E. Gonsalves, Examiner-in-Chief (Acting)	BOARD OF APPEALS

October 21, 1952
Moore, Olson & Trexler
135 South LaSalle Street

Chicago 3, Illinois

* * *

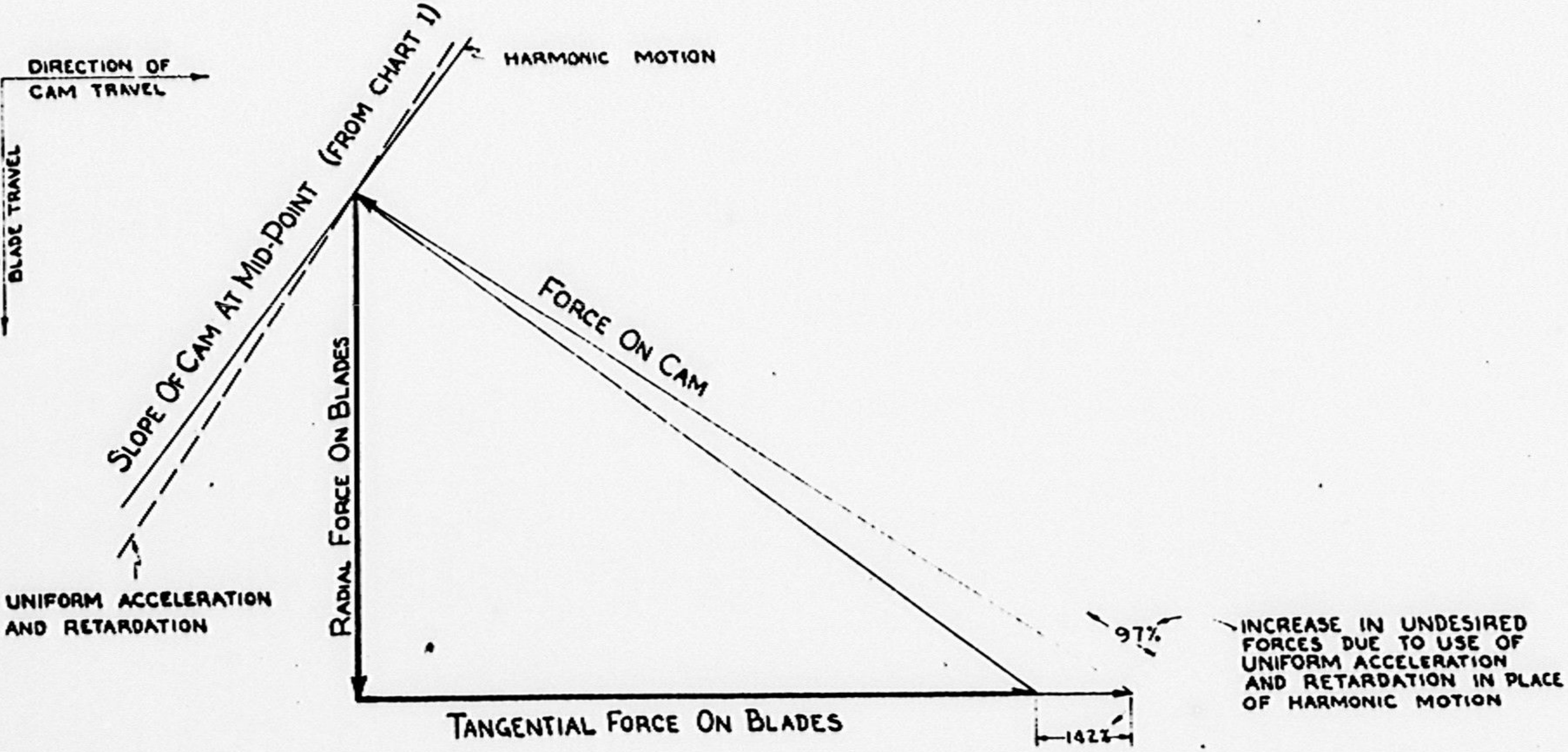
CHART I


- - - - - UNIFORM ACCELERATION & RETARDATION
9
4
9
4½
1.20573
——— SIMPLE HARMONIC MOTION

CAM PROFILE DIAGRAM

SVENSON vs WATSON
CIVIL ACTION No1778-5
PLAINTIFF'S
EXHIBIT No. 4

CHART II


DIRECTION OF CAM TRAVEL
DIRECTION OF BLADE TRAVEL
SLOPE OF CAM AT MID-POINT (FROM CHART 1)
HARMONIC MOTION
UNIFORM ACCELERATION AND RETARDATION
RADIAL FORCE ON BLADES
FORCE ON CAM
TANGENTIAL FORCE ON BLADES
97%
142%
INCREASE IN UNDESIRED FORCES DUE TO USE OF UNIFORM ACCELERATION AND RETARDATION IN PLACE OF HARMONIC MOTION

CAM FORCE DIAGRAM

SVENSON vs. WATSON
CIVIL ACTION No 1770-53
PLAINTIFFS EXHIBIT —No 5

Pl. Ex 7

Sumner v Miller
CA 11410-53
✓

ROTARY VANE PUMP TEST

PUMP MANUFACTURER: John S. Barnes Corporation

PUMP TYPE: N-491-GC

DATE OF TEST: 3-21-55

TEST RUN BY: Carl Linde

FLUID: Pennbell light **VISCOSITY:** 100 Saybolt Seconds

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MAR 21 1956
HARRY M. HULL, CLERK

Discharge Pressure Lb/Sq.In.	Discharge Volume Gal./Min.	Effective Volumetric Efficiency per cent	Overall Efficiency Per Cent
0	26.4	100	--
100	26.1	98.9	52.4
200	25.8	97.8	63.3
300	25.6	97.1	70.5
400	25.4	96.3	70.6
500	25.4	96.3	74.4
600	25.2	95.5	74.4
700	25.0	94.8	75.5
800	24.8	94.0	75.1
900	24.6	93.3	74.2
1000	24.4	92.5	73.4

No. 13253
Court of Appeals
For the
Circuit

CLERK

ROTARY VANE PUMP TEST

PUMP MANUFACTURER: Vickers, Incorporated

PUMP TYPE: V-134-U

DATE OF TEST: 3-18-55

TEST RUN BY: Carl Linde

FLUID: Pennbell light Viscosity: 100 Saybolt Seconds

Discharge Pressure Lb./Sq.In.	Discharge Volume Gal./Min.	Effective Volumetric Efficiency Per Cent	Overall Efficiency Per Cent
0	23.2	100	--
100	23.1	99.6	66.0
200	22.9	98.8	76.5
300	22.8	98.4	78.8
400	22.8	98.4	81.1
500	22.2	95.8	79.6
600	21.9	94.5	79.8
700	21.3	91.9	76.1
800	20.8	89.7	74.4
900	20.3	87.5	70.9
1000	19.7	85.0	68.4

[illegible]
[illegible]
Def. ex 1A

A

Aug. 15, 1933. W. G. HAWLEY **1,922,951**

ROTARY PUMP

Filed Feb. 3, 1930 3 Sheets-Sheet 1

FIG. 1.

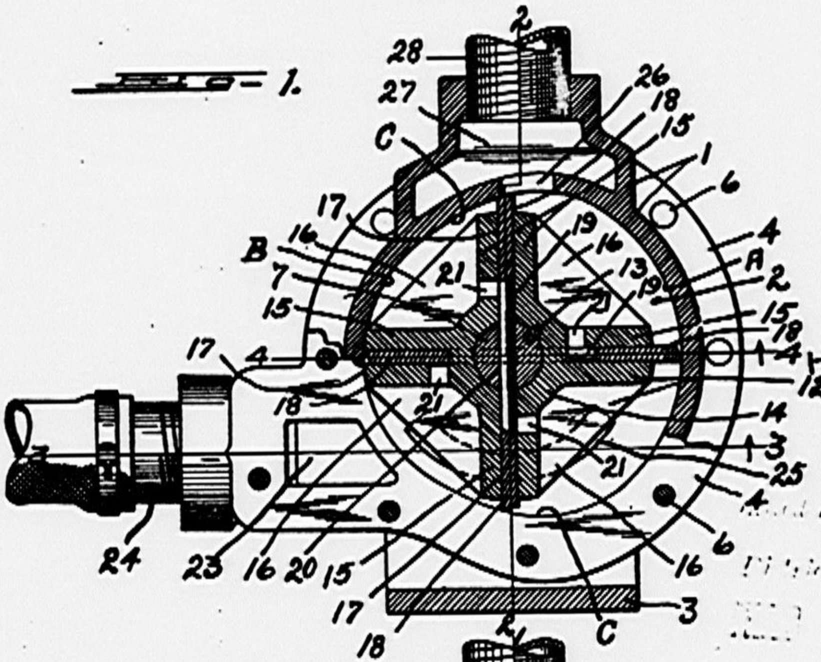
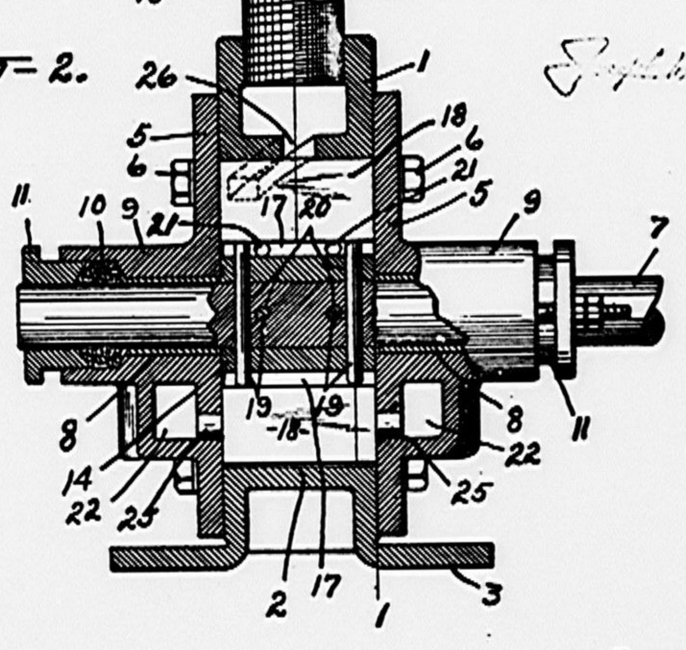


FIG. 2.



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MAR 21 1936

HARRY M. HULL, CLERK

No. 13253

United States Court of Appeals
For the
District of Columbia Circuit

FILED [illegible]

Joseph W. Stewart
CLERK

INVENTOR
BY W. G. Hawley

WITNESS
H. L. Meade.

Denison & Thompson
ATTORNEYS

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Aug. 15, 1933. W. G. HAWLEY **1,922,951**

ROTARY PUMP

Filed Feb. 3, 1930 3 Sheets-Sheet 2

Fig. 3.

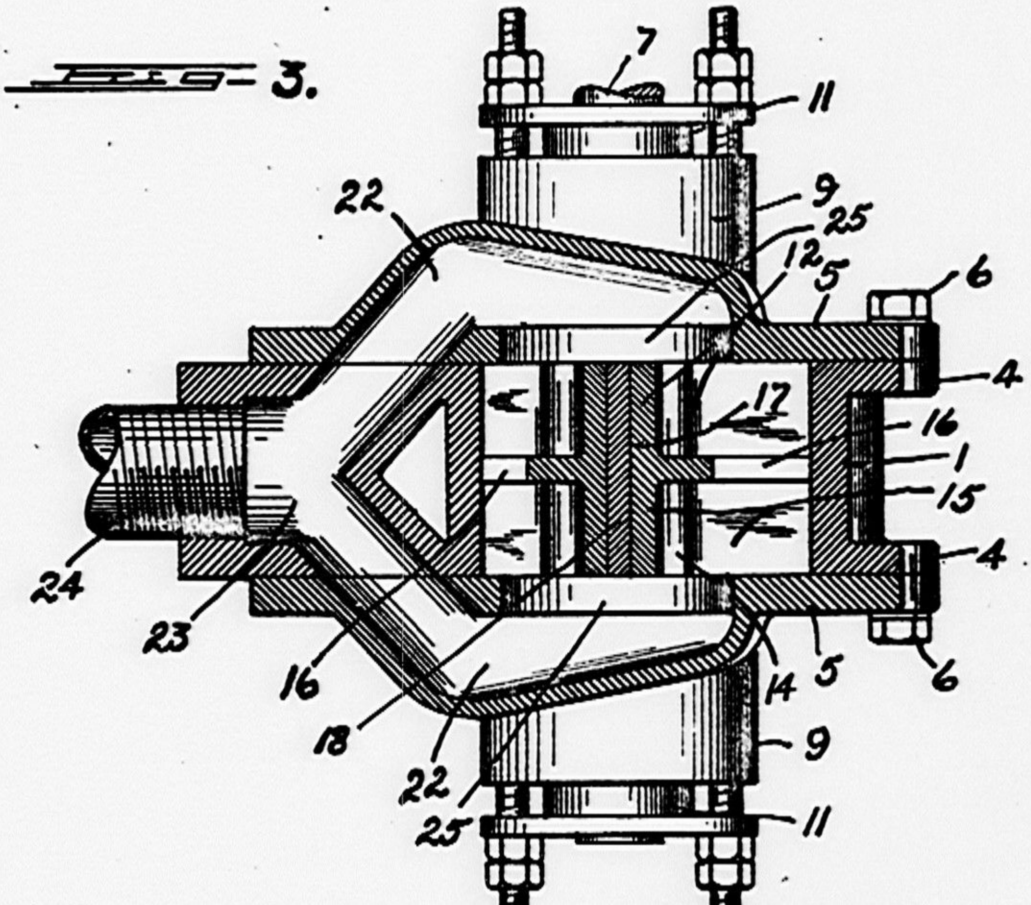
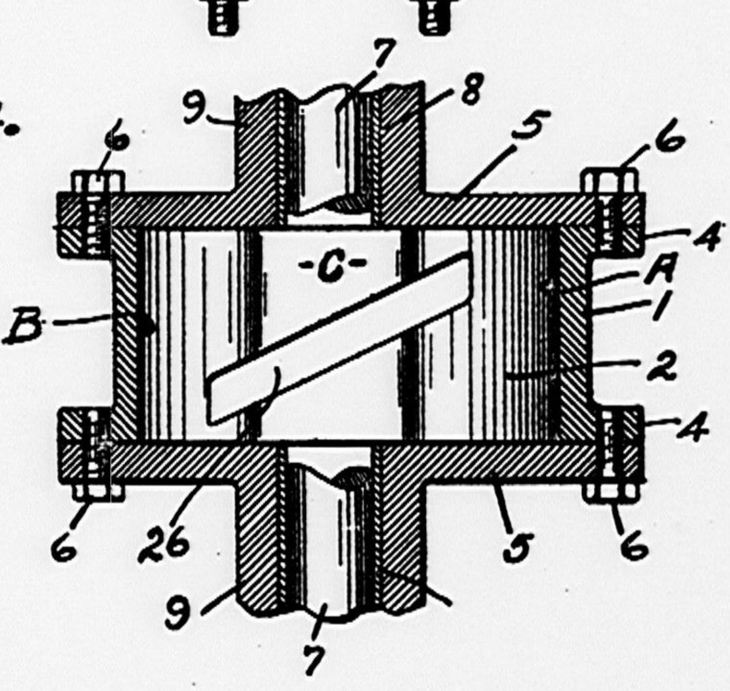


Fig. 4.



WITNESS

H. L. Meade.

INVENTOR

BY W. G. Hawley

Denison & Thompson

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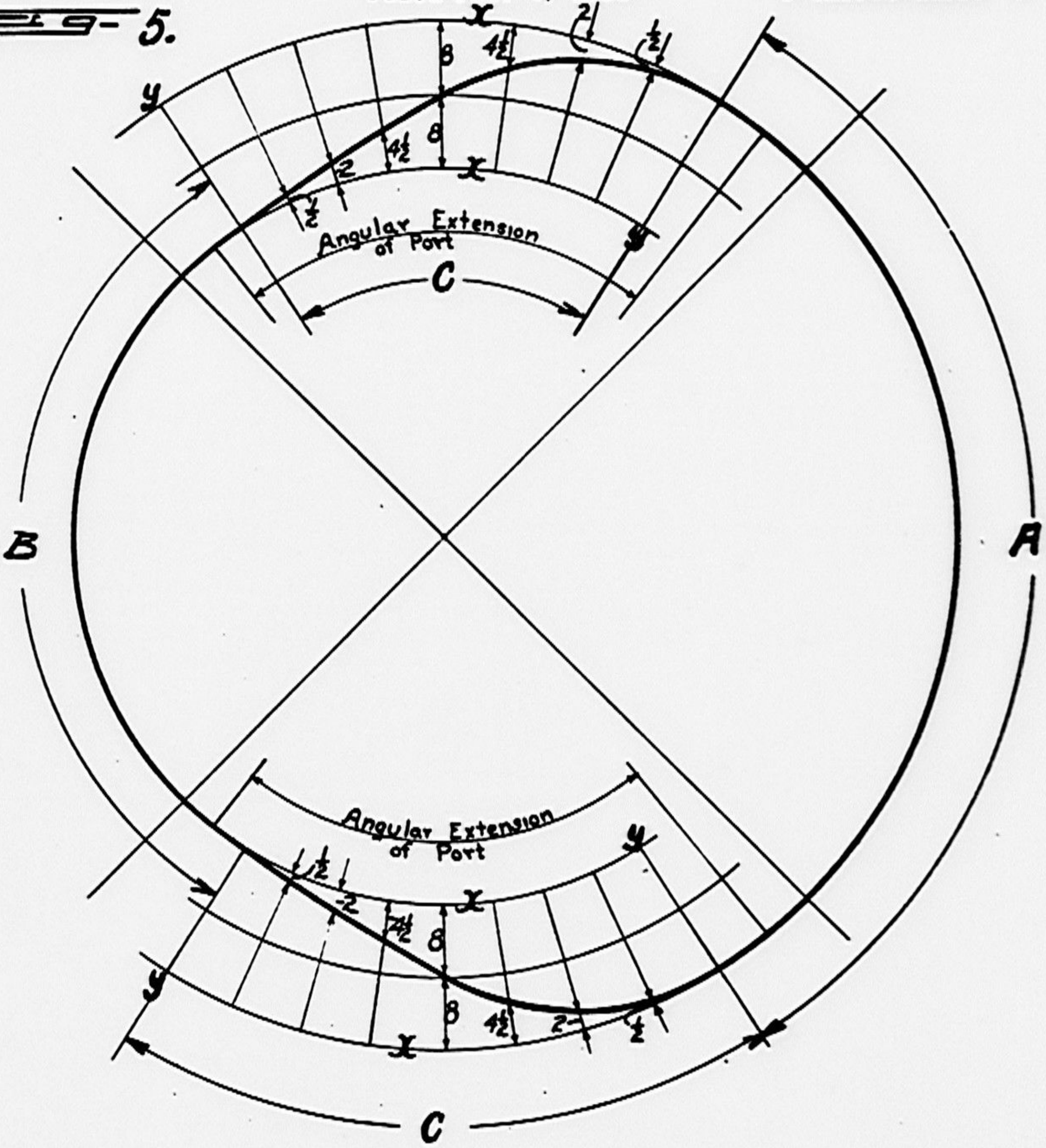
Aug. 15, 1933. W. G. HAWLEY 1,922,951

ROTARY PUMP

Filed Feb. 3, 1930 3 Sheets-Sheet 3

Fig. 5.



WITNESS

N. L. Meade.

INVENTOR

BY W. G. Hawley.

Denison & Thompson

ATTORNEYS

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Patented Aug. 15, 1933 **1,922,951**

UNITED STATES PATENT OFFICE

1,922,951

ROTARY PUMP

William G. Hawley, Elmira, N. Y.

Application February 3, 1930. Serial No. 425,501

1 Claim. (Cl. 103—138)

This invention relates to certain new and useful improvements in rotary pumps of the sliding impeller vane type.

The main objects of this invention are to provide a highly efficient rotary pump which is equally applicable for all forms of fluid, whether liquid or gaseous substances, which is susceptible of long life, and that may be constructed economically.

In carrying out the foregoing objects, I have provided a rotary pump having a rotor and a plurality of diametrically opposed impeller vanes operably mounted in said rotor, all of which are rotatably mounted in a suitable pump chamber concentrically with the major portion of the peripheral wall thereof, the contour of said peripheral wall being formed with two diametrically opposed circular arcs concentric with the rotor and having unequal radii, the included angles of said arcs being equal and greater than 90 degrees with their adjacent ends joined by means of a curved surface which is developed with uniform acceleration curves so that each vane in passing from one concentric arc to the other will be moved radially with a uniformly accelerated and retarded motion, thus guiding the vanes during the radial movements thereof, smoothly and without shock or noise and producing a substantially uniform discharge from the pump.

The inlet and the outlet ports for the pump are each positioned adjacent a respective curved portion of the peripheral wall of the pump chamber with the angular extension of said ports greater than the included angles of said curved portion so that each impeller vane is in registration with one of said ports during the radial movements of the vane, thus relieving any pumping pressure on the vane by equalizing the pressure on opposite sides thereof which reduces friction and wear and permits a high degree of efficiency in operation.

Another feature of this invention is to utilize the centrifugal force produced by the rotor and impeller vanes to assist in filling the pump by positioning the inlet port intermediate the peripheral wall of the pump chamber and the axis of the rotor.

Other objects and advantages pertaining to the details of the structure and the form and relation of the parts thereof will more fully appear from the following description taken in connection with the accompanying drawings wherein:—

Figure 1 is a face view of one side of the pump partly in section with a side plate removed, taken in the plane of the line 1—1, Figure 2.

Figure 2 is a vertical sectional view taken in the plane of the line 2—2, Figure 1.

Figure 3 is a horizontal sectional view through the inlet ports of the pump taken in the plane of the line 3—3, Figure 1.

Figure 4 is a detail horizontal sectional view taken in the plane of the line 4—4, Figure 1, with the rotor and a portion of the drive shaft removed.

Figure 5 is a diagrammatic view illustrating the contour of the peripheral wall of the pump chamber and generation of the curve on which said wall is made and the relative relation of the inlet and outlet ports.

As illustrated in the drawings, the pump consists of a suitable case —1— provided with an internal pump chamber —2—. The case is mounted on an integrally formed base —3—. At each end of the case is formed an annular flange —4— to which the end plates or cylinder heads —5— are secured by bolts or screws —6—.

A horizontally disposed drive shaft —7— is mounted concentric with the major portion of the pump chamber and is journaled in suitable bushings —8—, provided in outwardly projecting bearing members —9— made integral with the respective head or end plates —5—. The outer ends of each of the bearing members —9— may be provided with suitable packing —10— and follower —11— for preventing the escapement of fluid along the shaft —7—. One end of the drive shaft —7— may, as shown, extend outwardly beyond the respective bearing member —9— for receiving a pulley, not shown, or other suitable means for rotating said shaft.

A rotor —12— is mounted on the drive shaft —7— and positioned within the pump chamber —2—. The rotor, in this instance, is secured by a key —13— to the shaft —7— to rotate therewith although it is evident that the rotor may be made integral with said shaft. The rotor —12— is substantially the same length as the pump chamber —2— and consists, in this instance, of a tubular body portion —14— having a pair of diametrically opposed radial flanges —15— arranged at right angles to each other and extending lengthwise of the body portion —14— of the rotor —12— and may be tied together by a supporting transverse web —16— extending from one flange to the other substantially midway between the ends thereof.

Each flange —15— is provided with a radial slot —17— which extends lengthwise of the flange and from the outer end thereof inwardly to within a short distance of the drive shaft

—7—, each of said slots being adapted to receive an impeller vane —18—. These vanes are slidably mounted in a respective slot —17— for radial movement of the vanes caused by the outer longitudinal edge of said vanes riding over the irregular contour of the peripheral wall of the pump chamber —2— during the rotation of the rotor —12—. These vanes are of substantially the same length as the cylinder chamber —2— so that the outer ends thereof contact with the inner surface of the respective end plates —5— while the outer longitudinal edges of the vanes are held in constant contact with the peripheral surface of the pump chamber —2— by centrifugal force during the rotation of the rotor.

However, push rods, as —19— may be employed for each pair of vanes for maintaining the vanes in substantially constant contact with the peripheral wall of the pump chamber. These rods —19—, as illustrated in Figures 1 and 2, may be arranged in pairs, one pair for each pair of vanes, each pair of rods being slidably mounted in spaced holes —20— which extend diametrically through the axis of the drive shaft —7— and rotor —12— in the plane of the respective pairs of impeller vanes with the outer ends of the rods engaging the inner longitudinal edge of diametrically opposed vanes for holding said vanes in a predetermined spaced relation.

One or more holes or openings —21— may be provided in the front wall of each of the radial flanges —15— in communication with the base of the respective slots —17— for venting said slots at the bottom of each vane for permitting the fluid which is being pumped to pass freely in and out of said slots as the impeller vanes are moved radially, thus permitting the fluid pumped to be drawn into the slots as the vanes move outwardly and to force the fluid from the slots into the pump chamber at the discharge side of the rotor as the vanes are moved inwardly thus preventing an interruption of the discharge due to the vane displacement.

The contour of the peripheral wall of the pump chamber —12—, in this instance, is formed with a regular surface as more clearly illustrated in the diagrammatic view, Figure 5, said wall being formed with two diametrically opposed concentric circular arcs —A— and —B— of unequal radii and which are formed co-axially with the drive shaft —7— and rotor —12—.

The radius of the smaller arc —B— is substantially equal to the radius of the rotor —12— for permitting the free rotation of the rotor in said chamber as clearly illustrated in Figure 1. The included angles of the arcs —A— and —B— are equal and each greater than 90 degrees with the adjacent ends of said arcs joined by a curved surface—C—. These surfaces —C— are developed with uniform acceleration curves; that is, with curves developed with circular and radial co-ordinates concentric with the arcs —A— and —B—.

Referring now to Figure 5, —x— equals circular co-ordinates and —y— equals the radial co-ordinates and if —a— equals the radial accelerations per unit of circular motion, then the equation of the curve is —y— equals

$$\frac{ax^2}{2}.$$

By making —a— equal —1—, the equation becomes —y— equals

$$\frac{x^2}{2}$$

and when x equals 1, y equals ½; when x equals 2, y equals 2; when x equals 3, y equals 4½ and when x equals 4, y equals 8.

With the contour of the peripheral wall —C— of the pump chamber connecting the two concentric arcs —A— and —B— constructed in this manner with uniformly accelerated curves or some other forms of curves closely approximating this curve such as obtained from a development of a sine curve, the vanes —18— will be guided smoothly and without shock from one concentric arc to the other with a uniformly accelerated and retardation radial motion starting from rest on one arc and coming to rest on the other arc.

A pair of inlet passages —22— are provided for the pump chamber —2— and located one in each head or end plate —5— in a substantial horizontal plane below the axis of the drive shaft —7—. One end of each of the passages —22— is in communication with a common inlet chamber —23— provided in one side of the pump case —1— and which, in turn, is adapted to be connected by a pipe as —24— or other suitable means, to a source of fluid supply not shown.

The opposite ends of the passages —22— are each connected by an inlet or suction port —25— to the pump chamber —2—. The inlet ports —25— are positioned intermediate the body —14— of the rotor —12— and the path of movement of the outer ends of the flanges —15— and made concentric with the shaft —7— and the two concentric arcs —A— and —B—.

The ports are each in registration with the curved surface —C— located at the bottom of the pump chamber —2—, the circumferential length of each of said ports being sufficient to cause the ports to overlap the included angles of said curved surface; thus the outer ends of the ports are located beyond the radial plane of the ends of said curved surface so that both the front and rear surfaces of each impeller vane will be in registration with the inlet port before the vane reaches the respective curved surface —C— and before it leaves the smaller arc surface —B— and also for a short distance after the respective vane leaves said curved surface as it begins its travel along the larger arc —A—, thereby relieving any pumping pressure on the vane by equalizing the pressure on both front and rear surfaces of said vane which permits the free outward radial movement of the vane while passing over the curved surface —C— without excessive or undue friction.

The outlet or exhaust port —26— for the pump chamber —2— is located in the pump case —1— at the upper portion of the pump chamber —2— in registration with the upper positioned curved surface —C— of the peripheral wall of said pump chamber. The outlet port —26— is constructed similarly to the inlet port —25—in that the circumferential length of the curved surface —C— with the outer ends of said port positioned at equal distances either side of the curved surface so that as each vane, in turn, approaches the curved surface —C—, the forward and rear surfaces of said vane will be in registration with the port before the vane reaches the curved surface —C— and also for a short distance after it has passed said surface which equalizes the pressure on both side surfaces of the vane and permits the free inward radial movement thereof as it passes along the curved surface —C— in passing from the larger concentric arc —A— to the smaller arc —B—.

The exhaust port —26—, in this instance, is in communication with a suitable exhaust chamber —27— provided in the upper portion of the pump case —1—, said exhaust chamber being provided with a threaded opening in one side thereof for receiving an exhaust pipe as —28—.

Although I have shown and particularly described the preferred embodiment of my invention, I do not wish to be limited to the exact construction shown, as various changes both in the form and the relation of the parts thereof may readily be made without departing from the spirit of this invention, as set forth in the appended claim.

I claim:

In a rotary pump of the sliding vane type, a pump casing providing a chamber having a regular peripheral surface, a cross section of said surface taken in a plane normal to the axis thereof being composed of two diametrically opposed concentric arcs of unequal radii and uniform acceleration curves joining adjacent ends of said arcs so as to impart a uniformly accelerated and retardation motion in a radial direction when followed circumferentially, a rotor having radial flanges journaled in the case concentric with said arcs each of said flanges being provided with a radial slot, an impeller vane slidably mounted in each of said slots, a discharge port in the pump casing in registration with and overlapping one of said curved surfaces, and an inlet port in said casing communicating with the pump chamber intermediate the axis of the rotor and the path of movement of the outer ends of said flanges and overlapping the included angle of the other curved surface for balancing the pressure on opposite sides of said vanes during the entire radial movements thereof.

WILLIAM G. HAWLEY.

Feb. 5, 1935. **H. F. VICKERS** **1,989,900** ✓

VANE TYPE PUMP

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MAR 21 1956

HARRY M. HULL, CLERK

FIG. 6

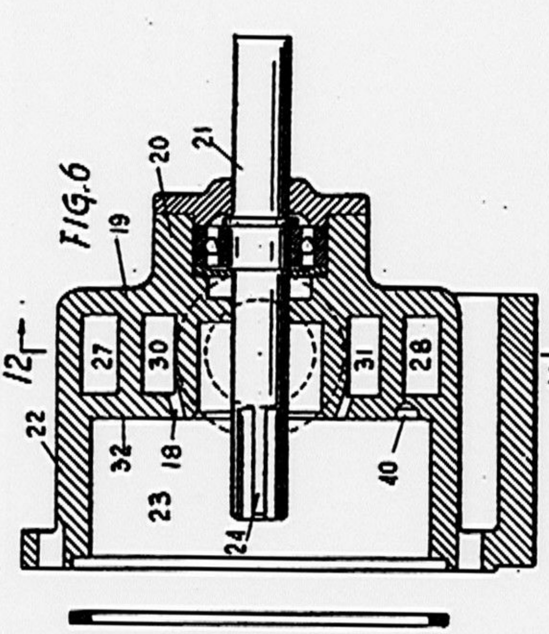
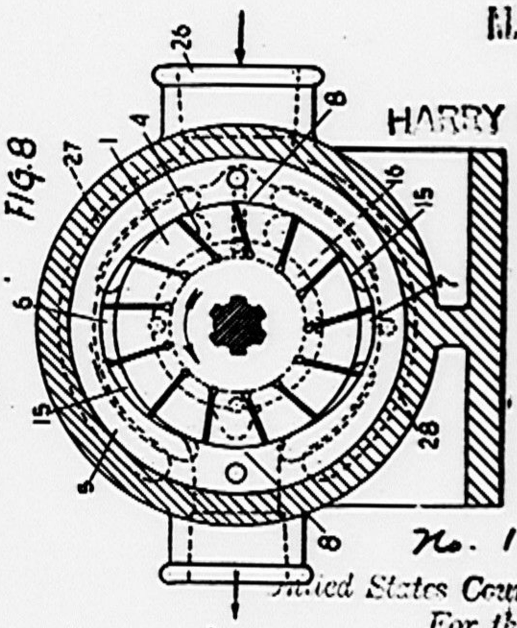


FIG. 8



No. 13257

United States Court of Appeals
For the
District of Columbia Circuit

FILED MAR 30 1956

Joseph W. Stewart
CLERK

F

FIG. 5

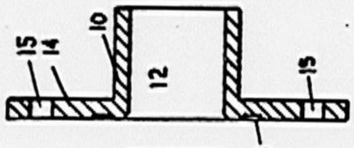


FIG. 4

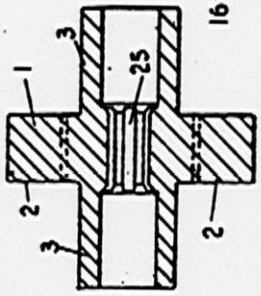


FIG. 3

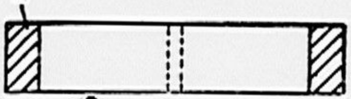


FIG. 2

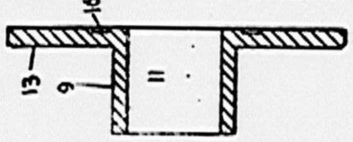


FIG. 1

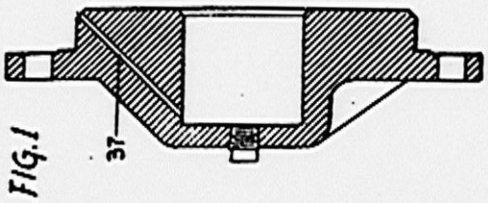
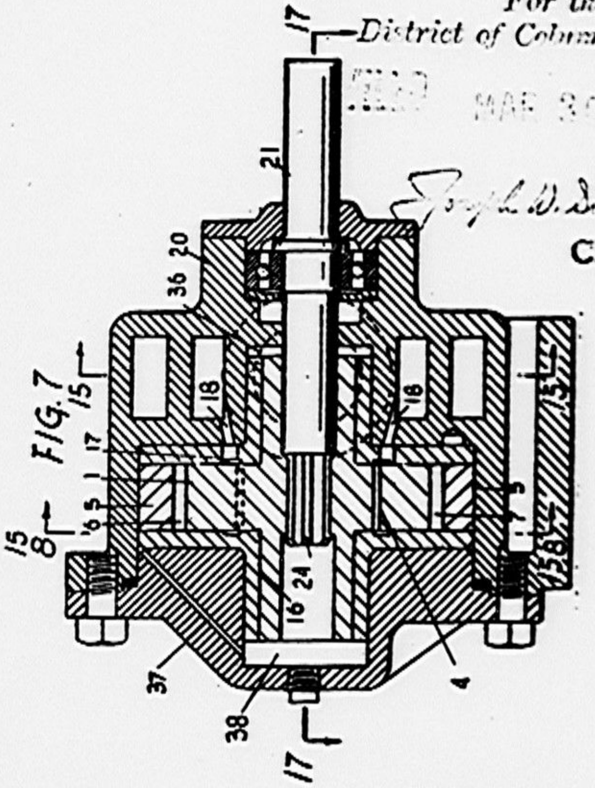


FIG. 7



INVENTOR.
HARRY F. VICKERS

BY

Barnes & Kisselle
ATTORNEYS

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VANE TYPE PUMP

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FIG. 9

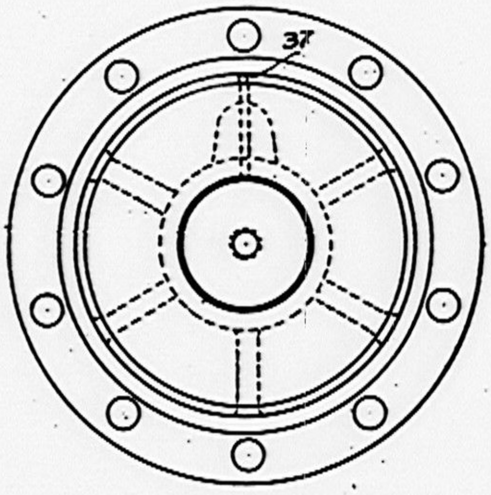


FIG. 11

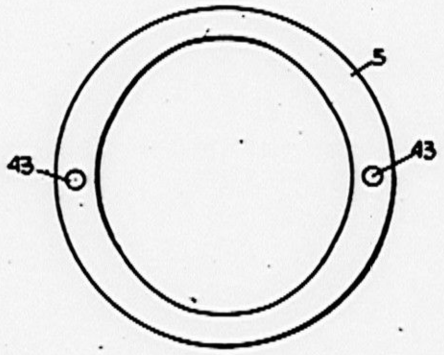


FIG. 10

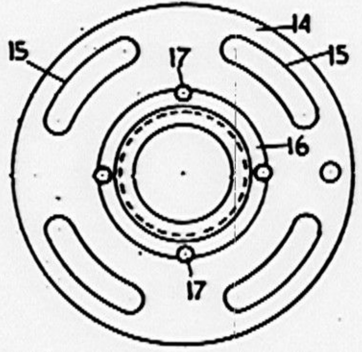


FIG. 12

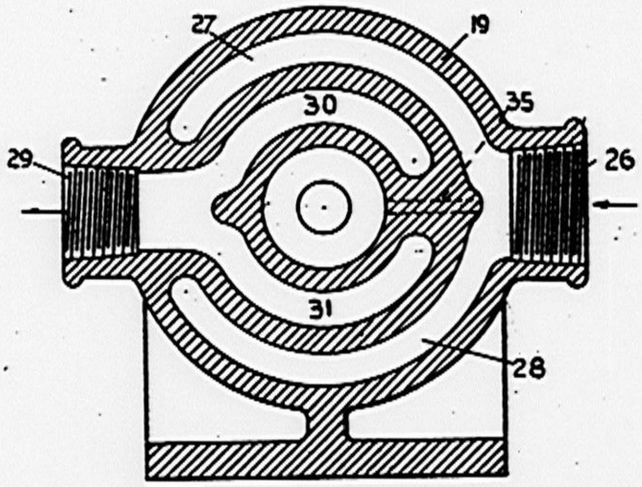


FIG. 13

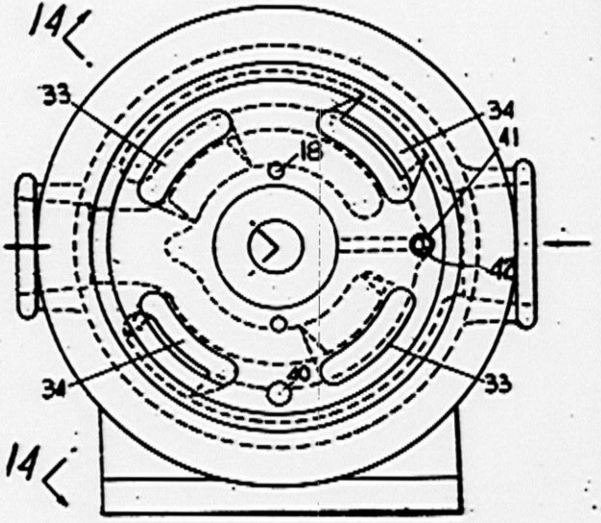
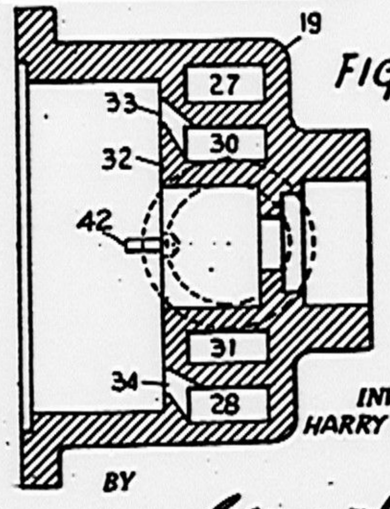


FIG. 14



INVENTOR.
HARRY F. VICKERS

BY

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VANE TYPE PUMP

Filed Jan. 15, 1931 3 Sheets-Sheet 3

FIG. 15

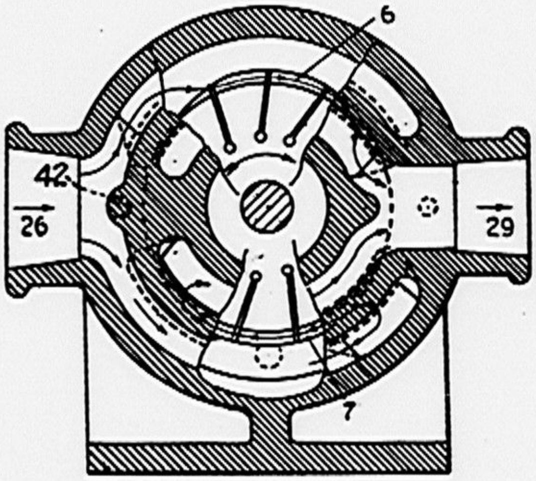
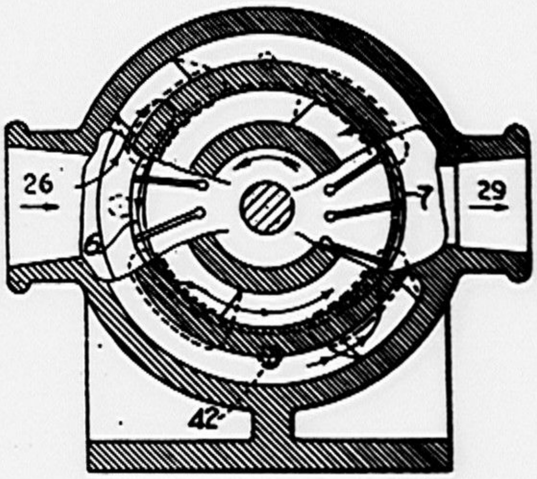


FIG. 16



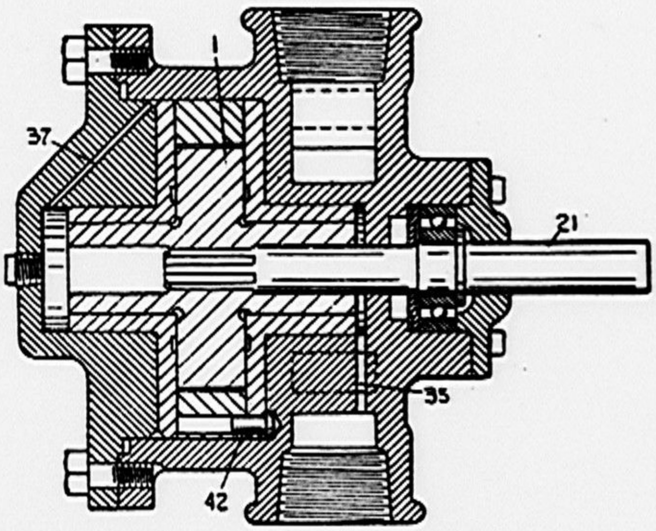


FIG. 17

INVENTOR.
HARRY F. VICKERS

BY

Barnes & Kisselle
ATTORNEYS

Patented Feb. 5, 1935 **1,989,900**

UNITED STATES PATENT OFFICE

1,989,900

VANE TYPE PUMP

Harry F. Vickers, Detroit, Mich.

Application January 15, 1931, Serial No. 509,011

15 Claims. (Cl. 103—135)

This invention relates to vane type pumps, and particularly to a simple, compact pump unit the parts of which cooperate to insure ease of assembly and a relatively great volumetric and mechanical efficiency.

One of the greatest draw-backs to extensive use of hydraulically actuated and controlled mechanism has been the inefficiency and short life of the pump unit designed to circulate the fluid under pressure. I have found this to be particularly true where the fluid is to be actuated and placed under relatively great pressure. Standard type gear pumps have been notably inefficient both volumetrically and mechanically with the result that they have presented a weak link in hydraulic systems.

It is the object of the present system to provide a rotary vane type pump the various parts of which cooperate in a novel manner to present a pump having relatively high mechanical and volumetric efficiency, and which parts also so coact and modify each other as to present an easily assembled, compact unit which will maintain such high efficiencies over a much longer period of time than has heretofore been believed to have been possible with rotary type pumps.

More specifically, the present invention contemplates a universally adaptable pump unit which may be said to be independent of the outer case or housing; in other words, this pump unit is complete in itself and may be readily assembled in connection with any type or shape of housing. The two-part housing itself is believed to be novel especially in the manner in which it cooperates with the pump unit.

Other important features reside in the construction and arrangement of the pump unit parts including flanges and bearings formed in one piece and cooperating in a novel manner with the pump casing and the pump rotor to insure free running and to prevent leakage; a liner cooperating with the flanges and with the housing to present a compact rigid structure and also to make possible the reversing of the pump; a balanced rotor formed by the combination of the housing, the flanges and the liner; and a freely mounted or "floating" rotor which aids materially in preventing wear and leakage.

Other novel features, the manner in which the parts cooperate, and the results obtained thereby will be more clearly brought out in the specification and claims.

In the drawings:

Figs. 1 to 6 illustrate the various main parts of my pump in their relative positions of assembly.

Fig. 7 is a sectional assembly view of the parts shown in Figs. 1 to 6.

Fig. 8 is a sectional view taken on line 8—8 of Fig. 7.

Fig. 9 is an end view of that part of the casing shown in Fig. 1.

Fig. 10 is an end elevation of the one piece flange and bearing unit shown in Fig. 5.

Fig. 11 is an end elevation of the liner ring shown in Fig. 3.

Fig. 12 is a sectional view through the casing shown in Fig. 6 and taken on line 12—12 of Fig. 6.

Fig. 13 is an end elevation of the casing shown in Fig. 6 and showing particularly the relative arrangement of inlet and outlet passageways and inlet and outlet ports.

Fig. 14 is a sectional view taken on line 14—14 of Fig. 13 and showing the manner of connecting the inner and outer passageways with the concentric ports.

Fig. 15 is a view similar to Fig. 8 but with a section taken on different planes to show the relative arrangement of the rotor vanes positioned to move in one direction and also the relative arrangement of the passageways and ports.

Fig. 16 is a view similar to Fig. 15 but showing the liner ring rotated 90° and the rotor reversed whereby the vanes are positioned to rotate in a direction opposite to that shown in Fig. 15.

Fig. 17 is a sectional view taken on line 17—17 of Fig. 7.

The novel features of the present invention will probably be best understood by explaining the manner in which the various parts thereof cooperate to make up my novel combined pump unit. While practically all the parts of my pump cooperate in a manner with each of the other parts and while some of the individual parts contain novel features of themselves, the gist of the invention resides in the combination.

Balanced rotor.—The heart of my rotary pump may be said to reside in the rotor unit as shown in Fig. 4. This rotor may be generally designated 1 and may consist of a cylindrical body portion 2 and axially projecting trunnions or bearing members 3. The body 2 of the rotor is slotted as best shown in Fig. 8 to receive relatively thin vanes 4.

Practically every part of my pump cooperates either directly or indirectly with this central rotor unit. The main body 2 of the rotor unit is adapted to snugly fit within an annular liner ring 5. The outer surface of this liner is circular in formation, as best shown in Fig. 8, but the inner surface is more of an elliptical shape to generally form the balanced working chambers 6 and 7. The greater part of the surfaces of the liner 5, which define the working chambers 6 and 7, are substantially concentric as are also the diametrically positioned portions 8 of the liner which receive and support the main body of the rotor. The curvature of the intermediate portions between the concentric surfaces just described is gradual and merges with said concentric surfaces with the result that the movement of the vanes 4 takes place as a gradual outward and inward movement and at points just prior to and after the development of pressure in the working chambers 6 and 7.

As will be subsequently brought out, the shape and dimensions of the working chambers 6 and 7 cooperate directly with the shape and arrangement of the inlet and outlet ports. Furthermore, the vanes of the rotor cooperate in a novel way with the inner surfaces of the liner to insure greater efficiency and incidentally greatly increase the life of the vanes as well as the ring 5. Not only are the vanes thin to reduce the bearing pressure at the ends thereof, but the vanes are tilted forward whereby to cause the pressure angle, tending to push the vanes into the rotor on the pressure side, to be at right angles to the line of motion of the vane. This also brings the center of gravity of the vane behind the trailing edge of the vane so as to prevent the vane from jumping as it leaves the inner circle on the tangent of the cam. It will, therefore, be obvious that this arrangement in addition to providing a balanced pressure for the rotor and thereby take the load off the bearings also makes it possible to obtain relatively great efficiency without appreciable wear of the vanes themselves. In other words, the vanes do not move relative to the rotor when they are under material pressure.

One-piece external bushing.—Instead of being directly supported in a case or housing, the extensions or bearings 3 of the rotor unit are supported by oppositely positioned one piece bushing units 9 and 10. These bushing units consist of the bearing members 11 and 12, which externally support the bearings 3 of the rotor, and laterally extending flanges 13 and 14. This forming of the bearings and flanges as an integral bushing unit permits the bushing units to be machined very accurately and easily and therefore not only permits of free running of the rotor but positively prevents any leakage at one of the important points of the assembly.

The liner ring 5 acts as a spacer for the two bushing flanges 13 and 14, and the machined surfaces of the flanges 3 and 4 being necessarily at right angles to the axis thereof, because of being formed of a single piece, it will be obvious that the side walls for the vanes 4 will present a very close fit due to this accurate machining and alignment. The flange 14 of the bushing unit 10 is provided with concentric circumferentially spaced inlet and outlet ports 15. These arcuate ports are relatively long and narrow for a specific purpose to be later described and each set of diametrically positioned ports form either the inlet or outlet ports according to the position of the liner and direction of rotation of the rotor. Each flange 13 and 14 is provided with an annular groove 16 on its inner face to insure equal and sufficient distribution of pressure over the entire lower surface of the vanes 4. The flange 14, in addition to the groove 16, is also provided with four equidistantly spaced apertures 17 adapted to register with ports 18 formed in the casing and connected to the high pressure passageways as will be later described. The four apertures 17 permit communication between the ports 18 and the groove 16 regardless of the position of the flange.

Combined distribution and supporting casing.—The main part of my casing unit which may be generally designated 19, as best illustrated in Fig. 6, preferably is so arranged as to properly distribute and circulate the fluid and also to carry the rotor shaft.

As best shown in Figs. 6 and 7, the casing unit is provided with an extension 20 and a rotor shaft 21 is adapted to be fixedly but rotatably positioned within said extension through the medium of a suitable packing gland, end thrust and roller bearings. The other end of the casing unit 19 is provided with an extension 22 forming a chamber 23 for receiving the complete pump unit consisting of the parts shown in Figs. 2, 3, 4, and 5. The inner end of the fixedly positioned shaft 21 is splined as at 24 to slidably receive a broached or corresponding slotted portion 25 formed in the rotor unit 1, as best shown in Fig. 4. Regardless of the particular manner of connecting the rotor to the shaft, the connection between the two is such that the rotor may adjust itself axially along the shaft so that the body of the rotor and the vanes will always automatically assume a central position between the flanges 13 and 14. This is an extremely important feature because if the rotor were not axially and freely positioned between the side walls the wear against one of the walls and the resulting leakage would materially reduce the efficiency of the pump. It will thus be seen that the rotor shaft may be fixedly installed within the casing unit or removed therefrom, independently of the pump unit or vice versa, and that the complete pump unit may be easily removed from the end of the rotor shaft without in any way disturbing such rotor shaft.

As best shown in Figs. 12, 13 and 14, the casing 19 is provided with an inlet 26 leading into concentric passageways 27 and 28, and an outlet port 29 leading from concentric passageways 30 and 31. The inner face 32 of the chamber 23 is provided with four concentric and circumferentially spaced openings which openings are preferably of substantially the same size and arrangement as the openings 15 formed in the flange 14. One set of diametrically positioned openings 33 are designed to be connected to the inner passageways 30 and 31 and another set of diametrically positioned openings 34 are connected to the outer passageways 27 and 28. Inasmuch as the openings 33 and 34 are arranged concentrically between the inner passageways and the outer passageways, such openings are connected to the passageways by means of angularly positioned ports, as best shown in Fig. 14. Regardless of the direction of rotation of the rotor or the position of the working chambers 6 and 7, the location of the inlet openings 34 and the outlet openings 33 is permanent. It will therefore be obvious that I may use many different types and shapes of casings so long as the inlet and outlet openings are arranged some way similar to that shown in Fig. 13.

The outlet passageways 30 and 31 become the pressure passageways while the inlet passageways 27 and 28 may be termed the induction passageways. As best shown in Figs. 12 and 17, the portion of the casing between the ends of the outlet passageways 30 and 31 and adjacent the inlet port 26 is provided with an opening 35 which connects the space 36 at one end of the rotor shaft with the induction passageways. The casing cap, as best shown in Fig. 1, is provided with a conduit 37, which, as best shown in Fig. 7 connects the periphery of the pump unit with a space 38 formed at the other end of the rotor. The location of this conduit makes certain that any fluid under pressure and escaping between the flanges and the rotor will pass through the conduit 37, axially through the rotor, and along the rotor shaft to the space 36 and into the induction passageways. While the one piece bushing units 9 and 10 act as a seal, the conduit just described insures that any leakage of the fluid under pressure takes the path of least resistance.

As best shown in Figs. 13 and 14, the wall 32 of the casing is provided with two positioning holes 40 and 41, either one of which is adapted to receive a pin 42 for positioning the flange 14 and the liner ring 5. With the rotor and liner in the position shown in Fig. 8, the pin 42 will be in the hole 41. As the ring member 5 is reversible, apertures 43 are provided on each side of the ring member. When it is desired to reverse the direction of movement of the rotor, the rotor body is removed, turned around and inserted so that the vanes are tilted forward in the opposite direction, as best shown in Fig. 16. When this is done the pin 42 is removed from the hole 41 and placed in the hole 40, and the ring member and flange 14 moved correspondingly. This arrangement moves the working chambers 90° as will be seen by comparing Figs. 15 and 16.

Assembly and operation.—In assembling my novel pump unit, the casing unit may be first assembled as shown in Fig. 6 and the pin 42 inserted in the proper hole according to the direction of rotation of the rotor. Next, the four elements forming the independent pump unit; namely, the flange and bearing unit 9, the liner 5, the rotor 1, and the flange and bearing unit 10, may be assembled together and inserted as a unit, or the respective parts inserted in order in the casing 19. The casing cap, as best shown in Fig. 1, may then be inserted in place whereby the flanges 13 and 14 and the liner ring 5 are securely and solidly held in place, leaving the rotor element 1 freely mounted on the end rotor shaft 21 whereby said rotor body may centralize itself between the faces of the flanges 13 and 14.

When the rotor shaft is rotated in the direction shown in Figs. 8 and 15, fluid is drawn in through the intake 26 and is directed into the passageways 27 and 28 and thence into the diametrically arranged openings 34, as best shown in Figs. 13 and 14. As the slots 15 of the flange 14 register with the respective openings 33 and 34 in the casing and as the liner ring 5 is definitely positioned relative to such ports or slots 15, it will be seen that the surfaces of the working chambers 6 and 7 bear a definite relationship to the openings 15. This relationship is best illustrated in Figs. 8, 15 and 16.

The arcuate ports 15 are of sufficient length as to register with those portions of the working chamber surfaces which permit outward movement of the vanes 4. Thus the outward and inward movement of the vanes 4 takes place while in registry with the inlet and outlet ports 15. There is no movement of the vanes through the central part of the working chambers 6 and 7 with the result that the vanes do not move radially while they are under pressure.

The fluid placed under pressure in the working chambers 6 and 7 passes out through the diametrically positioned discharge ports which cooperate with the discharge ports 33 formed in the casing 19 and which communicate with the passages 30 and 31.

In addition to the natural tendency of the vanes to contact with the surfaces of the liner due to the centrifugal action, these vanes are maintained outwardly under positive pressure by reason of the fact that the apertures 17 in the flange 14 are in direct communication with the ports 18 leading from the high pressure passageways 30 and 31. The high pressure acts evenly all the way across the back of the vanes because of the annular groove 16 formed in each of the inner faces of the flanges 13 and 14. The one piece flanges and bearings act as inner seals from the high pressure groove behind the vanes into the case. This furnishes an automatic high pressure lubricating supply to these rotor supporting bearings as well as acting as a seal. As the flanges 13 and 14, and the liner 5 form the complete case for the rotor, it will be obvious that there is no pressure on the case or packing which positively prevents any spring of the case cover and subsequent leakage.

The operation of the pump upon reversing the position of the rotor is much the same except that the working chambers are so arranged relative to the inlet and outlet ports that the entrance of the fluid is at the opposite side of the working chambers (compare Figs. 15 and 16).

It will thus be seen that I have provided a rotary vane type pump unit the parts of which are very simple and compact in construction and assembly, and all of which cooperate in a way to provide not only easy assembly but relatively great efficiency over a long period of time. The various parts of the pump cooperate especially in reducing wear at the most vital points.

What I claim is:

1. In a vane type rotary pump, the combination of a casing having pressure chambers and balanced intake and exhaust ports, a rotor shaft fixedly mounted in said casing, and a pump unit consisting of a rotor, a solid liner and one piece flange bearings slidable as a unit on said rotor shaft, only one of said flanges having balanced intake and exhaust openings registering with the balanced intake and exhaust ports formed in the casing, and an aperture in said flange positioned adjacent the bearing portion thereof and connecting a pressure chamber in the casing with a concentric groove formed in said flange and an inner portion of the rotor for conducting fluid from said pressure chamber to the inner edges of the vanes.

2. In a vane type rotary pump, the combination of a casing having pressure chambers and balanced intake and exhaust ports at one end of the casing for controlling the flow of all working fluid to and from the pump, a rotor shaft fixedly mounted in said casing, a pump unit consisting of a rotor, one piece liner and flange bearings slidable as a unit on said rotor shaft, one of said flanges having balanced intake and exhaust openings registering with the balanced intake and exhaust ports formed in the casing, and an aperture positioned adjacent the junction of the flange and bearing and connecting a pressure chamber in the casing with a concentric groove formed in said flange and an inner portion of the rotor for conducting fluid from said pressure chamber to the inner edges of the vanes, and means for fixing said flange and liner in position

but allowing free axial movement of the rotor on said shaft.

3. In a vane type rotary pump, the combination of a casing having intake and exhaust passageways at one end of the casing for controlling the flow of all working fluid to and from the pump, a rotor shaft fixedly mounted in a bearing at said end of the casing, a rotor having axially extending trunnions and a one piece flanged bearing in axial alignment with said rotor shaft bearing for receiving and supporting one of said trunnions, said rotor having a floating arrangement with said shaft, the flange of said bearing forming one of the walls of a rotor chamber for receiving said rotor and having ports cooperating with the intake and exhaust passageways in the casing for conducting fluid to and from the rotor, and an aperture positioned adjacent the bearing and passing through the flange for connecting a pressure chamber in the casing with an inner portion of the rotor for conducting fluid from said pressure chamber to the inner edges of the vanes, said casing, flange bearing and trunnion cooperating to form a seal against by-passing of pressure.

4. In a vane type rotary pump, the combination of a casing having intake and exhaust passageways, a rotor shaft fixedly mounted in said casing, a rotor having axially extending trunnions and a one piece flanged bearing in axial alignment with said shaft mounting for receiving and supporting one of said trunnions, the flange of said bearing forming one of the walls of a rotor chamber for receiving said rotor and having ports cooperating with the intake and exhaust passageways in the casing for conducting all the working fluid to and from one side of the rotor, said flange also having balanced ports cooperating with the exhaust passageways in said casing for supplying fluid under pressure to the inner edge of the vanes.

5. In a vane type rotary pump, the combination of a casing having intake and exhaust passageways, a rotor shaft, a rotor having axially extending trunnions and a one piece flanged bearing for receiving and supporting one of said trunnions, the flange of said bearing forming one of the walls of a rotor chamber for receiving said rotor and having ports cooperating with the intake and exhaust passageways in the casing for conducting all the working fluid to and from one side of the rotor, said flange also having balanced ports cooperating with the exhaust passageways in said casing for supplying fluid under pressure to the inner edge of the vanes.

6. In a vane type rotary pump, the combination of a casing having concentrically arranged and radially spaced intake and exhaust passageways, diametrically positioned intake and exhaust ports converging from said concentric passageways, a rotor shaft, a rotor mounted on said shaft and having a radially extending body with radially reciprocable vanes, a liner cooperating with said radially extending body to form balanced working chambers, and a one piece bearing flange having concentric circumferentially spaced openings cooperating with said intake and exhaust ports for conducting fluid to and from said working chambers.

7. In a vane type rotary pump, the combination of a casing having concentrically arranged and radially spaced intake and exhaust passageways, diametrically positioned intake and exhaust ports, a rotor shaft, a rotor mounted on said shaft and having a radially extending body with radially reciprocable vanes, a liner cooperating with said radially extending body to form balanced working chambers, a one piece bearing flange having concentric circumferentially spaced openings cooperating with said intake and exhaust ports for conducting fluid to and from said working chambers, and a groove in said flange for supplying fluid under pressure to the inner edges of said vanes.

8. In a rotary vane type pump, the combination of a casing having intake and exhaust chambers and balanced concentric intake and exhaust ports in one wall of said chambers, a rotor shaft fixedly mounted in said casing, a rotor having its own bearings, radially reciprocable vanes in said rotor, one piece members forming bushings for said bearings and side walls of a rotor chamber for receiving said rotor, balanced working chambers at the periphery of said rotor, one of said side walls having ports registering with said first named ports for conducting fluid to and from said working chambers, and an aperture in said wall adjacent said bushing and connecting the exhaust chamber with the back of said vanes.

9. In a rotary vane type pump, the combination of a casing having intake and exhaust chambers and balanced intake and exhaust ports in one wall of said chambers, a rotor shaft, a rotor having its own bearings, radially reciprocable vanes in said rotor, one piece members forming bushings for said bearings and side walls of a rotor chamber for receiving said rotor, balanced working chambers at the periphery of said rotor, one of said side walls having ports registering with said first named ports for conducting all the working fluid to and from said working chambers, and an aperture in said wall adjacent said bushing and connecting the exhaust chamber with the back of said vanes.

10. In a rotary vane type pump, the combination of a casing having concentrically arranged balanced intake and exhaust chambers and ports at one end thereof, a rotor shaft fixedly mounted in said end of the casing, a rotor having its own bearings, one piece members forming bushings for said bearings and side walls of a rotor chamber for receiving said rotor, working chambers at the periphery of said rotor, only one of said side walls having ports registering with said first named ports for conducting all the working fluid to and from said working chambers, a closure cap for the casing having an oil conduit connecting one of said walls with the interior of one of said rotor bearings.

11. In a rotary vane type pump, the combination of a casing having balanced intake and exhaust chambers and ports at one end only, a rotor shaft, a rotor having its own bearings, one piece members forming bushings for said bearings and side walls of a rotor chamber for receiving said rotor, balanced working chambers at the periphery of said rotor, only one of said side walls having ports registering with said first named ports for conducting fluid to and from the inner wall of said working chambers, and an aperture in said wall adjacent said bushing and connecting the exhaust chamber with the back of said vanes, the vanes on said rotor being tilted forward in the direction of rotation, said rotor being removable from the end of the casing opposite said chambers and reversible for changing the position of said working chambers according to the direction of rotation of the rotor.

12. In a rotary vane type pump, the combination of a casing having balanced intake and exhaust chambers and ports at one end only, a rotor shaft, a rotor having its own bearings, one piece members forming bushings for said bearings and side walls of a rotor chamber for receiving said rotor, balanced working chambers at the periphery of said rotor, one of said side walls having ports registering with said first named ports for conducting fluid to and from the inner wall of said working chambers, and an aperture in said wall adjacent said bushing and connecting the exhaust chamber with the back of said vanes, the vanes on said rotor being tilted forward in the direction of rotation, said rotor being removable from the end of the casing opposite said chambers and reversible for changing the position of said working chambers according to the direction of rotation of the rotor without changing the general direction of fluid flow through the pump.

13. In a vane type rotary pump, the combination of a casing having at one end bilateral intake and exhaust passageways, a rotor shaft fixedly mounted in the end of the casing having said passageways, a portion of the casing extending axially to form a chamber, and a pump unit within said chamber, said unit consisting of a rotor, vanes in said rotor, a liner shaped to form balanced working chambers at opposite sides of said rotor, flanges forming side walls for said rotor and working chambers and having integral bushings for supporting the rotor, and diametrically positioned ports in one of said flanges cooperating with said passageways and working chambers for conducting fluid to and from the working chambers, and means for positioning said liner and ported flange relative to the casing.

14. In a vane type rotary pump, the combination of a casing having bilateral intake and exhaust passageways, a rotor shaft fixedly mounted in said casing, a portion of the casing extending axially to form a chamber, and a pump unit within said chamber, said unit consisting of a rotor, vanes in said rotor, a liner shaped to form balanced working chambers at opposite sides of said rotor, flanges forming side walls for said rotor and working chambers and having integral bushings for supporting the rotor, and diametrically positioned ports in one of said flanges cooperating with said passageways and working chambers for conducting fluid to and from the working chambers, and means for positioning said liner and ported flange relative to the casing, a portion of the liner forming each working chamber being concentric to maintain the vanes radially stationary during the working stroke.

15. In a mechanism of the character described, a casing having a chamber, concentric, radially spaced passageways between said chamber and an end wall of the casing, a shaft extending into the chamber and fixed at only one end in said end wall, a rotor on the shaft including a radial body and axial trunnions, a liner defining balanced working chambers at the periphery of the rotor, means connecting said working chambers and passageways said shaft being freely slidable relative to said rotor and terminating substantially within the plane of said radial body, a bearing in the chamber having a tubular portion seated in a socket in the casing and surrounding the trunnion and a flange slidably supporting a side of the radial body, and means for rotating the rotor.

HARRY F. VICKERS.

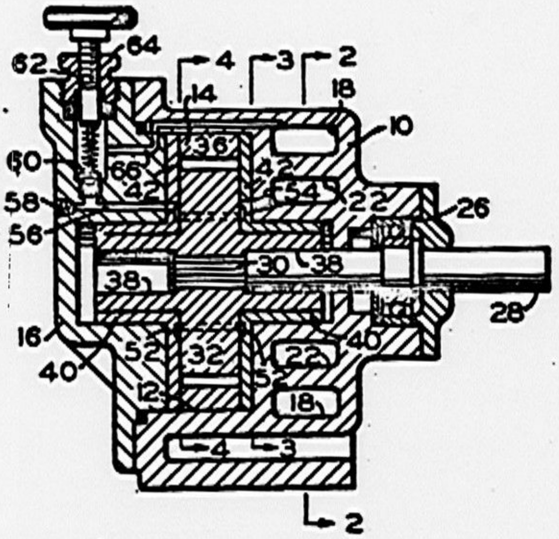
Nov. 26, 1946. R. L. TWEEDALE **2,411,602**

PUMP FOR POWER TRANSMISSION

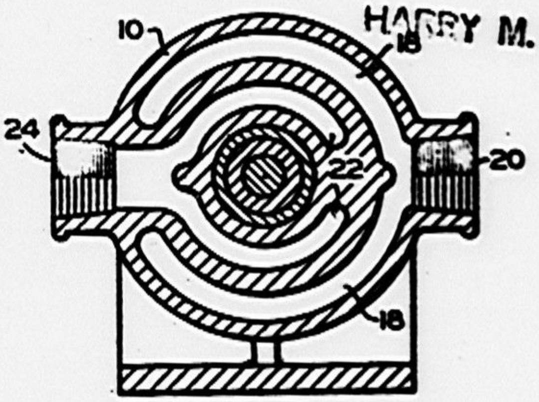
Filed Sept. 3, 1942

FILED
MAR 21 1956
HARRY M. HULL, CLERK

FIG—1



FIG—2



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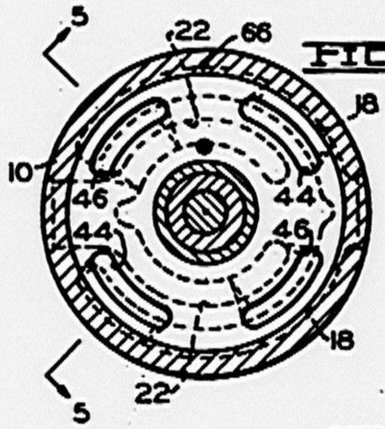
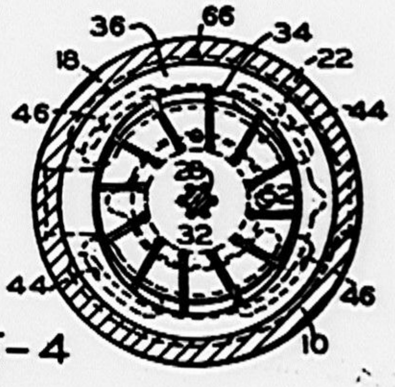
FIG—3

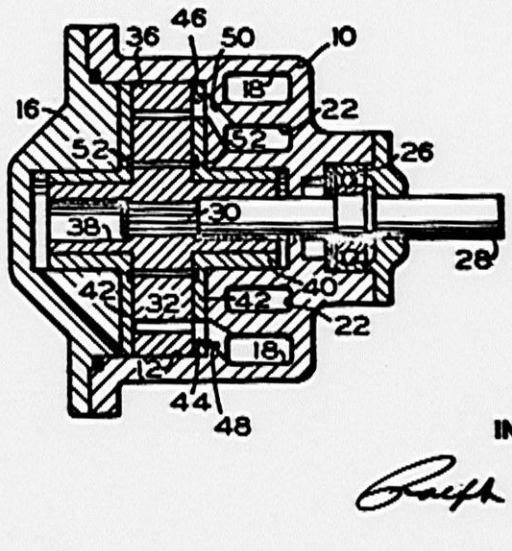




FIG—4

No. 13253

FIG—5



INVENTOR

Ralph L. Tweedale

Patented Nov. 26, 1946 **2,411,602**

UNITED STATES PATENT OFFICE

2,411,602

PUMP FOR POWER TRANSMISSIONS

Ralph L. Tweedale, Birmingham, Mich., assignor to Vickers Incorporated, Detroit, Mich., a corporation of Michigan

Application September 3, 1942, Serial No. 457,161

4 Claims. (Cl. 103—120)

This invention relates to power transmissions, particularly to those of the type comprising two or more fluid pressure energy translating devices, one of which may function as a pump and another as a fluid motor.

The invention is more particularly concerned with a pumping unit of the rotary type and with control means for regulating the volumetric discharge thereof.

A form of pump in common use in the hydraulic power transmission field utilizes a rotor having a plurality of substantially radial vanes rotatable therewith and slidable relative thereto. The rotor and vanes cooperate with a stator member which defines one or more pumping chambers through which the vanes pass carrying fluid from the inlet port to the outlet port. Pumps of this character have heretofore been provided with pressure relief valves for bypassing the fluid delivered by the pump and returning it to the pump suction inlet through a bypass passageway, either for limiting the maximum pressure in the pump discharge line or for completely unloading the pump to permit it to circulate fluid idly.

It is an object of the present invention to provide an improved pumping unit which may be so controlled as to act as its own relief valve or unloading valve, as the case may be.

A further object is to provide a unit of this character wherein the radial movement of the vanes relative to the rotor may be variably controlled to thereby regulate the pumping action and reduce or increase, to any degree desired, the volumetric rate of delivery.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred form of the present invention is clearly shown.

In the drawing:

Figure 1 is a longitudinal cross section of a pump incorporating a preferred form of the present invention.

Figure 2 is a cross section on line 2—2 of Figure 1.

Figure 3 is a cross section on line 3—3 of Figure 1.

Figure 4 is a cross section on line 4—4 of Figure 1.

Figure 5 is a cross section on line 5—5 of Figure 3.

A body 10 is provided with a cylindrical recess 12 in which is fitted a pumping cartridge 14, being retained therein by a head plate 16 re-

movably secured to the body 10 by bolts, not shown. The body 10 is provided with an arcuate suction port 18 communicating with a suction pipe connection 20 and radially inward thereof is provided with a smaller arcuate pressure port 22 communicating with a pressure pipe connection 24.

Journalled upon a bearing 26 in the housing 10 is a drive shaft 28 which at its inner end has a splined connection 30 with a cylindrical rotor block 32 in the cartridge 14. The block 32 is provided with a plurality of generally radial slots in which are positioned vanes 34, as seen in Figure 4, the vanes being radially movable inwardly and outwardly within the slots.

The cartridge 14 includes a ring member 36 having a cylindrical external shape and an approximately oval internal shape against which the ends of the vanes 34 contact. The rotor 32 is provided with hollow hubs 38 which run in bearings 40, forming part of the cartridge 14. The bearings 40 have integral flange portions 42 which overlie the side faces of the rotor 32 and the ring 36. The righthand flange 42 is provided with arcuate suction ports 44 and arcuate discharge ports 46 which appear in Figures 3 and 5. The ports 44 communicate by inclined passages 48 with the suction passageway 18, while the ports 46 communicate by an inclined passage 50 with the discharge passageway 22.

The flanges 42 are provided with groves 52 which extend 360 degrees around their inner faces at a point adjacent the inner end of the slots in the rotor. The grooves 52 thus provide access connection to the space in the slots beneath the vanes 34. The righthand groove 52 connects with the discharge passage 22 by means of a restricted passage 54 in Figure 1. The lefthand groove 52 connects by means of a passageway 56 with a pipe connection 58 and with a pilot relief valve 60. The later is spring-loaded to open at a predetermined pressure in the passage 56, which pressure may be adjusted through the medium of a spring-adjusting screw 62 having a lock nut 64. When the valve 60 is open, fluid passing therethrough is carried to the suction passage 18 through a duct 66 formed in the end plate 16 and the body 10.

With the exception of the restricted passage 54 and the parts which lead off from the passage 56, the pump may be constructed similarly to that illustrated in the patent to Harry F. Vickers, No. 1,989,900, to which reference is made for disclosure of certain detail features omitted from the present drawing for the sake of clarity.

In operation, assuming that the inlet connection **20** is connected with a suitable reservoir of oil or other liquid, and that the outlet connection **24** is in communication with a suitable work circuit, with the shaft **28** being driven, the rotor **32** revolves counterclockwise in Figure 4, carrying with it the vanes **34**. At pressures below the setting of the pilot relief valve **60**, the operation of the pump is identical to that described in the previously mentioned Vickers patent, and oil is carried from the suction ports to the discharge ports, the vanes **34** sealing the space between the rotor **32** and ring **36** at the diametrically opposite top and bottom points in Figure 3.

It will be noted that the liquid in the grooves **52** is under the full pressure of the pump discharge since there is no flow through the restricted orifice **54** and consequently no pressure drop therethrough. This is because there is always the same number of vanes moving inwardly as there are moving outwardly at any instant and the total volume of fluid in the groove **52** and the slots connected thereto remains constant. Thus, the vanes **34** are projected outwardly as they pass across the suction ports **44** in Figure 4. This is the normal pumping action of the device.

When the delivery pressure against which the pump discharges rises to a value higher than that for which valve **60** is adjusted, the valve opens, permitting liquid to escape from the groove **52** through passage **56**, valve **60** and passage **66**. This causes a flow to take place through the restriction **54**, and, as the flow rate increases, the pressure drop through the restriction **54** increases, and there is accordingly less pressure applied to the under surface of the vanes **34**. When this tendency has progressed to the point where the difference in pressure between that applied to the outer end of a given vane as it approaches one of the pressure ports **46** and the pressure applied to the inner end of the same vane is a greater difference than the centrifugal force applied to that particular vane, then the vane will be forced slightly inwardly, permitting oil to escape between the outer face of the vane and the inner face of the ring **36**. In this way, high pressure oil from the discharge port **46** may flow back past the end of the vanes **34** to the suction port **44**. Thus, the net delivery of the pump is reduced, and consequently tends to reduce the pressure in the discharge passage **22** until it eventually falls to a value where the valve **60** again closes, and normal action is restored.

In applications where it is never necessary to completely unload the pump, the pipe connection **58** may be plugged with a suitable pipe plug, and the device then provides merely overload pressure-limit protection. In the event, however, that it is desired to interrupt the delivery of fluid by the pump without stopping the rotation of shaft **28**, the connection **58** may be used as a "vent" connection to unload the pump at will. Thus, the duct **56** may be opened by removing the plug in connection **58** or it may be connected to a remotely operable on-off valve which, when it is opened, will connect the duct **56** to an exhaust point, such as the oil reservoir, and instantly drop the pressure beneath the vanes to a very low value. Accordingly, the vanes will be pushed inwardly as they approach the pressure port, and this action will continue until the discharge pressure has fallen to a value just necessary to overcome the centrifugal force tending to push the vanes outwardly.

In addition, it may be desired to vary the quantity of fluid delivered by the pump without completely unloading it. In such case, the plug may be loosened to permit leakage or the on-off valve may be so constructed or operated (e. g., a needle valve) as to variably restrict the exhaust from groove **52**. By loosening the plug or opening this valve to a greater or less extent, its resistance may be varied relative to the resistance of restriction **54**, and consequently the pressure beneath the vanes may be regulated to become any desired percentage of the discharge pressure, and the degree of slippage of the pump is correspondingly varied.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. A rotary vane type pump having a pump stator having a fluid working chamber having inlet and outlet ports, a rotor member mounted in the fluid working chamber, one of said members having recesses therein, alternately retractable and extendable vanes mounted in said recesses for sealing the passage of fluid between the pump outlet and inlet, means forming a pressure chamber communicating with the recesses, the pressure in which is effective to urge the vanes outwardly, a permanently open, restricted passage connecting the pressure chamber with the pump outlet, and a pressure responsive relief valve connected between the chambers and an exhaust point responsive to and limiting the maximum pressure in the chamber to vary the amount of extension of the vanes when a predetermined pressure is reached at the pump outlet to thereby vary the amount of slippage past the vanes in a manner to maintain pump outlet pressure constant.

2. A single, self-contained, self-regulating pump unit comprising a single pump of the rotary, multiple-vane type, a pump stator having a fluid working chamber having inlet and outlet ports, a rotor member mounted in the fluid working chamber, one of said members having recesses therein, vanes mounted in said recesses for inward and outward movement, fluid pressure means for causing movement of the vanes outwardly during a phase of pump rotation, a pressure-responsive relief valve of small capacity with respect to the pump capacity, means for causing said relief valve to govern the outward movement of the pump vanes whereby the slippage of the pump may be purposely increased to maintain pump discharge pressure within a predetermined limit, and additional means governing movement of the pump vanes by cooperation with said first means and effective to unload the pump independently of said relief valve.

3. A single self-contained, self-regulating pump unit comprising a single pump of the rotary vane type, a pump stator having a fluid working chamber having inlet and outlet ports; a rotor member mounted in the fluid working chamber, one of said members having recesses therein, vanes mounted in said recesses for inward and outward movement, a pressure chamber in permanently open but restricted communication with the discharge side of the pump and effective to maintain the vanes fully projected into pumping position wherein slippage is

a minimum, and means effective to vent said chamber and prevent full projection of the vanes whereby pump slippage may be increased to substantially 100 per cent.

4. A rotary pump comprisng in combination a stator having a pumping chamber therein, a rotor in said chamber and having a plurality of recesses and vanes rotatable therewith and movable relative to the rotor in a generally radial direction in said recesses, said chamber and rotor being formed to provide a working space, means forming an inlet port and an outlet port for fluid being pumped, said ports being spaced apart and separated by said vanes in passing through said working space, and means selectively operable to vary the movement of the vanes relative to the rotor and thereby connect the inlet and outlet ports, said means including a permanently-open restricted connection between the outlet port and said recesses and a normally-closed passage leading to an exhaust point and means to open said passage for at times exhausting said recesses.

RALPH L. TWEEDALE.

Filed Dec. 21,1955 by Harry M. Hull, Clerk

UNITED STATES DISTRICT COURT
For the District of Columbia

ERNEST J. SVENSON,
Plaintiff,
v.
ROBERT C. WATSON,
Commissioner of Patents,
Defendant.

C. A. 1770-53

MEMORANDUM

Claims 31 and 32, drawn to the cam structure, are not inventive by virtue of the cited prior art. That being the view the Court takes, there is no need as a consequence to address itself to whether or not they are unpatentable as a mere statement of function. Whether or not the decision of the Supreme Court in *General Electric Co.* v. *Wabash,* 304 U.S. 364 has been overruled or modified by the change in the statute, in the view taken, is not pertinent, and this Court as a consequence expresses no opinion.

The method claims 11, 12, 13, and 30 are likewise not inventive by virtue of the prior art cited.

Counsel will prepare tentative findings of fact and conclusions of law and proper order.

/s/ Matthew F. McGuire
Matthew F. McGuire
United States District Court

December 21, 1955.

Filed Feb. 3, 1956 by Harry M. Hull, Clerk

57 United States District Court
For the District of Columbia

Ernest J. Svenson, Plaintiff v. Robert C. Watson, Commisioner of Patents Defendant	Civil Action No. 1770-53

FINDINGS OF FACT

1. This is a civil action brought under the provisions of 35 U. S. C. 145 in which the plaintiff as the applicant in an application for patent entitled "Cam Structure and Method of Manufacture", Serial No. 644,627, filed January 31, 1946, sought to have the Court authorize the issuance of a patent to him containing claims 11, 12, 13, 30, 31, and 32 of that application.

Claims 11, 12, 13, and 30

2. Claims 11, 12, 13, and 30 are drawn to the method of making the cam structure. As expressed in claim 11, the method broadly involves assuming a circular base line, adding the ordinates of a sine curve progressively to the base line, and forming a cam track for the cam structure along the sine-like line thus determined. In a specific 58 aspect, as set forth in claims 12 and 30, the method additionally includes modifying the line computed by adding the ordinates of the sine-curve progressively to the circular base line in accordance with the shaping of a machining tool adapted to machine the cam track, forming a matrix cam surface in accordance with the modified line thus determined, and guiding the machining tool in accordance with the matrix cam surface. In a further

particular aspect, as recited in claim 13, the method includes the use of a circular machining tool: a grinding wheel.

3. As principal references, the United States patents to Johnson, No. 2,259,472, Rosen, No. 2,445,971, and Rybicky, No. 2,247,412, each disclose the machining of elements by use of templates or a cam, and plaintiff so conceded. In such a disclosure, these patents satisfy the requirement of claim 11 as to forming a cam track for the cam structure along the sine-like line determined, and of claims 12, 13, and 30 respecting guiding the machining tool in accordance with the matrix cam surface. These patents further teach the positioning of a ring-like member adjacent the matrix cam with a cutting tool disposed on the inner surface of the ring-like member and controlled in its movements by the matrix cam for forming the ultimately desired cam structure along the inner surface of said ring-like member, as specified in claim 30.

59 4. As the single subsidiary reference, the publication, "Elements of Mechanism", by Schwamb, Merrill and James, 4th Ed., 1930 (John Wiley and Sons), discloses at pages 216 to 236, the remaining features of claims 11, 12, 13, and 30, which are cam design features. With respect to the recital in claims 11, 12, and 13 of adding the ordinates of a sine curve progressively to a circular base line, and a similar recital in claim 30, Fig. 276 at page 218 of the publication shows the development of a cam with which a body may be made to move with a harmonic motion. A sine curve imparts simple harmonic motion. Laying out the ordinates of a sine curve on a circular base line—on an arc between adjacent ends of spaced circular portions of a cam at different radial distances from the center of the cam—involves no more than adapting and adjusting, in an obvious manner, the sine

curve to the riser surface bridging the circular cam portions to afford smooth transition between the circular cam portions. On pages 219 to 221 of the publication, particularly in Figs. 278 and 280, there is a teaching of how to modify the sine-like line in accordance with the shaping tool, so that the matrix cam may be formed on the modified line, as specified in claims 12 and 13 and indicated in claim 30.

5. Applying the teachings of cam design set out in the stated pages and figures of the identified publication, "Elements of Mechanism", to the method of forming a cam track and structure disclosed in the cited patents to Johnson, Rosen, and Rybicky would not require the exercise of invention.

60 6. Method claims 11, 12, 13, and 30 are not inventive by virtue of said prior art cited.

7. Method claims 11, 12, 13, and 30 are unpatentable over each of the patents to Johnson, Rosen, and Rybicky, in view of the publication, "Elements of Mechanism".

Claims 31 and 32

8. Claims 31 and 32 are drawn to the cam structure. As expressed in claim 31, such structure, which is for use with rotary blade pumps including translatably mounted blades, comprises a ring-like body having a substantially circular outer surface and having an internal surface including a plurality of cam tracks formed therein. Each of the cam tracks is, according to the language of claim 31, constructed and arranged to impart harmonic motion simultaneously to the translatably mounted blades when rotation occurs between the blades and one of the cam tracks and to cause actuation of said blades. To produce a balanced load on the cam structure, the cam

tracks are located opposite one another. Claim 32 additionally recites that the cam tracks are joined by a plurality of circular surfaces.

9. As a principal reference, the United States patent to Vickers, No. 1,989,900, discloses a pump cam in the form of an annular liner ring, within which the main body
of the associated rotor unit snugly fits. The outer
61 surface of the annular liner ring is circular, while the
inner surface is more of an elliptical shape, to form
balanced working chambers. Spaced surfaces of that entire inner surface are substantially concentric, but the curvature of the intermediate portions between the concentric surfaces is gradual and merges with the concentric surfaces with the result that the movement of vanes or translatable mounted blades of the rotor unit takes place as a gradual outward and inward movement.

10. As a further principal reference, the United States patent to Tweedale, No. 2,411,602, shows as a pump cam a ring member with a cylindrical eternal shape, and an approximately oval internal shape against which the ends of vanes contact.

11. As the sole subsidiary reference, the patent to Hawley, No. 1,922,951, shows a rotary pump in which the peripheral wall of the pump chamber may have the contour illustrated in Fig. 5 of the patent, to cause impeller vanes or translatably mounted blades to move radially. Such peripheral wall includes surfaces C connecting arcs A and B of unequal radii. Hawley particularly states that each surface C may, in one instance, be constructed with a curve such as obtained from a development of a sine curve. A sine curve gives simple harmonic motion.

12. Invention would not be involved in modifying the ring cam structures disclosed in the Vickers and Tweedale

patents in accordance with the teachings of the Hawley patent so that a plurality of cam tracks would be contructed and arranged to impart harmonic motion simultaneously to translatably mounted blades, and would
62 be joined by a plurality of circular surfaces.

13. Claims 31 and 32, drawn to the cam structure, are not inventive by virtue of the aforesaid cited prior art.

14. Claims 31 and 32 are unpatentable over each of the patents to Vickers and Tweedale in view of the patent to Hawley.

15. In consequence of the findings that claims 31 and 32 are not inventive by virtue of the cited prior art and are unpatentable thereover, there is no need to pass upon the question whether said claims are functional as attempting to define over the patents to Vickers and Tweedale at the very point of alleged novelty by a bare statement of function. Whether or not the decision of the Supreme Court in *General Electric Co.* v. *Wabash,* 304 U. S. 364, has been overruled or modified by the third paragraph of 35 U. S. C. (1952) 112, in the view so taken, is not pertinent. As a consequence, no opinion is expressed thereon.

Conclusions of Law

1. Plaintiff is not entitled to a patent containing any of claims 11, 12, 13, 30, 31, and 32 of his application, Serial No. 644,627, in suit.

63 2. The complaint should be dismissed as to all the claims in suit.

/s/ Matthew F. McGuire
Judge

February 3, 1956

Filed Feb. 3, 1956 by Harry M. Hull, Clerk

64 UNITED STATES DISTRICT COURT
For the District of Columbia

ERNEST J. SVENSON, Plaintiff v. ROBERT C. WATSON, Commissioner of Patents Defendant	Civil Action No. 1770-53

JUDGMENT

This action came on to be heard at the April term, 1955, and thereupon consideration thereof, it is this day of 3d of February, 1956

ADJUDGED that the complaint be and it is hereby dismissed, with costs against the plaintiff.

/s/ Matthew F. McGuire
Judge

APPROVED AS TO FORM:

/s/ Roy H. Olson
Attorney for Plaintiff

Filed Feb. 20, 1956 by Harry M. Hull, Clerk

65 IN THE UNITED STATES DISTRICT COURT
For the District of Columbia

ERNEST J. SVENSON,
Plaintiff
v.
ROBERT C. WATSON,
Commissioner of Patents
Defendant

Civil Action
No. 1770-53

NOTICE OF APPEAL

Notice is hereby given that Ernest J. Svenson, Plaintiff in the above-entitled action, hereby appeals to the United States Court of Appeals for the District of Columbia from that part of the judgment entered in this action on February 3, 1956 which dismissed his complaint as to claims 31 and 32.

/s/ Charles L. Sturtevant
/s/ Charles L. Sturtevant
813 National Press Building
Washington 4, D. C.

/s/ Roy H. Olson
/s/ Roy H. Olson
141 West Jackson Boulevard
Chicago 4, Illinois

/s/ Edward A. Haight
/s/ Edward A. Haight
209 South La Salle Street
Chicago 4, Illinois
Attorneys for Plaintiff

(Mail copy to Clarence Moore, Solicitor, U.S. Patent Office)

February 20, 1956

BRIEF FOR APPELLANT.

IN THE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA

Appeal No. 13,253

ERNEST J. SVENSON,
Appellant,
vs.
ROBERT C. WATSON, Commissioner of Patents,
Appellee.

Appeal from the United States District Court
for the District of Columbia

CHARLES L. STURTEVANT
813 National Press Building
Washington, D. C.

ROY H. OLSON
141 W. Jackson Blvd.
Chicago 4, Illinois

EDWARD A. HAIGHT
209 South LaSalle St.
Chicago 4, Illinois
Attorneys for Appellant.

The Scheffer Press, Inc.—ANdover 3-6850

United States Court of Appeals
For the
District of Columbia Circuit
FILED JUN 8 1956

STATEMENT OF QUESTIONS PRESENTED.

1. The principal question is whether a patent application claim is properly rejected as being obvious to those of ordinary skill in the art when the evidence shows that the problem had existed for some years; that appellant's solution had not occurred to those skilled in the art; that the teachings of the prior art cited would lead away from and not toward appellant's solution; and that appellant's devices had gone into commercial use and demonstrated superiority in efficiency and in minimizing the adverse effects of wear.

2. A second question raised in the Patent Office but not relied upon by the District Court in support of the judgment herein is whether a patent claim may properly define cam tracks as "being constructed and arranged to impart harmonic motion" in view of a statute authorizing the definition of an element "as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof" (Act of July 19, 1952, c. 950 § 1, 66 Stat. 798, USC, Title 35, § 112.)

IN THE

UNITED STATES COURT OF APPEALS

For the District of Columbia

Appeal No. 13,253

ERNEST J. SVENSON,
Appellant,
vs.
ROBERT C. WATSON, Commissioner of Patents,
Appellee.

Appeal from the United States District Court
for the District of Columbia

BRIEF FOR APPELLANT.

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JURISDICTIONAL STATEMENT.

This is a civil action under Act of July 19, 1952, c. 950, § 1, 66 Stat. 803, USC, Title 35, § 145, by the plaintiff-appellant, Ernest J. Svenson, the applicant in application for Letters Patent Ser. No. 644,627, against the Commissioner to issue a patent on that application to plaintiff-appellant (Complaint, Joint App. 1a—7a; Answer, Joint App. 7a-8a; Finding 1, Joint App. 92a).

The District Court for the District of Columbia dismissed the complaint (Joint App. 97a). This appeal is under Act of June 25, 1948, c. 646, 62 Stat. 929, USC, Title 28, § 1291.

STATEMENT OF THE CASE.

This is an action seeking an adjudication that plaintiff is entitled to the grant of a patent. The application involved is that of Ernest J. Svenson, Ser. No. 644,627 entitled "Cam Structure and Method of Manufacture" (Joint App. 29a-50a). The complaint sought an adjudication that Svenson was entitled to six claims (Joint App. 1a-7a). The District Court dismissed the complaint as to all claims (Joint App. 91a-97a). Svenson appealed to this Court only as to Claims 31 and 32 (Joint App. 98a).

The Svenson application discloses an improved cam structure for use in a rotary blade pump, and also a method of manufacturing it. The claims involved on this appeal are directed to the cam structure. They read (Joint App. 6a, 7a):

> 31. A cam structure for use with rotary blade pumps including translatably mounted blades and comprising a ring-like body having a substantially circular outer surface and having an internal surface including a plurality of cam tracks formed therein, each of said cam tracks being constructed and arranged to impart harmonic motion simultaneously to the translatably mounted blades when relative rotation occurs between the blades and one of the cam tracks and to cause actuation of said blades, the said cam tracks being located diametrically opposite one another causing associated blades to move in harmonic motion outwardly and inwardly, whereby to produce a balanced load on the cam structure.
>
> 32. A cam structure as claimed in claim 31, wherein the cam tracks formed in the internal surface of the ring-like body are joined by a plurality of circular surfaces connecting the said cam tracks.

In a rotary blade pump, or vane pump, movable blades or vanes are located in generally radial slots in a central rotor. A cam is positioned outside of the blades so that it controls their radial position and also serves as the peripheral wall of the chamber in which pressure is developed. The blades are urged outwardly by fluid pressure from the discharge or high pressure side of the pump and also by centrifugal force (Joint App. 10a). The outer edges of the blades contact and seal against the cam itself. As the rotor turns, and as each blade passes adjacent to an inlet port, the cam permits it to move radially outward; as each blade passes adjacent to an outlet port, the cam forces it inward (Joint App. 13a). A pump of this general type is shown in the Vickers Patent No. 1,989,900 (Joint App. 79a).

These pumps are used for supplying large volumes of fluid in hydraulic equipment such as machine tools, hydraulic presses, elevator mechanisms, etc. (Joint App. 11a). Pressures are developed up to 1500 or 2000 pounds per square inch (Joint App. 14a). The pumps are operated at from 900 to 1800 revolutions per minute, 1200 revolutions per minute being preferred (Joint App. 14a).

The principal problems in pumps of this type are "wear, vibration and hammering of the blades as they contact the cam, the loss of seal between the blades and the cam path proper" (Joint App. 14a).

The wear to which the blades and cam are subjected is evident. Operating at 1200 rpm, each blade reciprocates 40 times each second; and each portion of the cam is subjected to 240 scraping actions each second (Joint App. 14a). As the blades frictionally engage the cam with this rapidity, they are urged outwardly against it by centrifugal force and also by the discharge pressure of the pump, which may be as high as 2000 pounds per square inch (Joint App. 10a, 14a). In addition to wear at their outer ends, where the blades contact the cam, there is wear along the face of the blades where they contact the rotor. The slots are not precisely radial, and so there is a circumferential force acting on the blades which tends to lock them in their slots (Joint App. 18a-19a). There is, therefore, scraping between each blade and the rotor at the rate of 40 reciprocations, or 80 movements each second of operation at 1200 rpm (Joint App. 14a).

The problem of vibration and hammering of blades is likewise evident. Operating at 1200 rpm, each blade reciprocates 40 times per second and there are 12 blades per pump, producing 480 reciprocations or 960 blade movements per second (Joint App. 14a). Improper cam contour, either in the original pump or resulting from wear, can result in hammering and still further wear (Joint App. 29a).

Prior to Svenson the art, as shown in this record, treated cam contour as of no great significance. Two prior art patents showing the general type of pump to which the Svenson invention is applicable are in the record (Vickers 1,989,900, Joint App. 79a and Tweedale 2,411,-602, Joint App. 89a). One of them defines the cam surface as not circular but "more of an elliptical shape" (Joint App. 82a, col. 2, lines 53-55), and the other defines it as "approximately oval" (Joint App. 88a, col. 2, lines 16-19). The only other patent cited against the claims involved in this appeal (Hawley 1,922,951, Joint App. 73a-78a) discloses a pump having sliding vanes but of the unbalanced type with but a single inlet and outlet and in which the forces involved and the problem of vibration will differ from those here involved. The Hawley patent suggests that the vanes in his type pump should be moved with "a uniformly accelerated and retarded motion" (Joint App. 76a, col. 1, lines 25 and 26). The District Court did not refer to Hawley's basic disclosure but merely to a single phrase of Hawley's specification which stated that an approximation of a uniform acceleration curve "such as obtained from a development of a sine curve" would produce uniform acceleration and retardation (Joint App. 95a).

The cam disclosed by Svenson is shown as element 10 in Figs. 1 and 4, the internal cam track being designated as 16 (Joint App. 47a, 48a). The cam has two sets of opposed cylindrical surfaces, those of larger diameter being designated 24 and those of smaller diameter designated 22. Between these sets of cylindrical surfaces or circular segments are four rise portions designated 26. The application discloses the formation of these rise portions so that simple harmonic motion will be imparted to the blades as they pass from one circular segment to another (Joint App. 30a, 32). These rise portions constitute a sinusoidal curve transferred from a straight line base (Fig. 3) to a circular base (Fig. 2, Joint App. 47a).

The Svenson cams have been manufactured in substantial numbers by John S. Barnes Corporation, of which appellant Svenson is president and general manager (Joint App. 9a, 25a-26a). Those pumps have been sold in competition with Vickers pumps and there are appreciable differences in result between the Barnes pumps employing the Svenson cam and the Vickers pumps presumably employing the "elliptical" shape of the Vickers patent or "oval" shape of the Tweedale patent assigned to Vickers. In a comparison recently made between a Vickers pump and the Barnes pump employing the Svenson cam, the Vickers pump dropped in effective volumetric efficiency from 100%

at 0 pounds per square inch discharge pressure to 85% at 1000 pounds per square inch, while the Barnes pump dropped to only 92.5 (Joint App. 26a, 71a, 72a). Another improvement effected in the cam over the prior art cam is the difference in the wear pattern. The wear on the Svenson cam appears over the entire length of the rise whereas the wear of the Vickers cam is concentrated at the point at which the cam has the smallest inside diameter (Joint App. 29a). As to the significance of this, Harold Olson, Research Engineer for the John S. Barnes Corporation testified (Joint App. 29a):

> "Of course, any variation in the shape of the path causes a variation in the reciprocal motion of the blades. And the wear concentrated more at one point tends to cause the blade to move very rapidly at that point and introduce a hammering action which is detrimental for two reasons. First, the blade tends to bounce back when it hammers; and second, of course that introduces additional vibration."

STATUTES INVOLVED.

The sections of the statute giving this Court jurisdiction have been mentioned above. The statutes involved on the merits of the appeal are:

> Act of July 19, 1952, c. 950, § 1, 66 Stat. 798, USC Title 35 § 103:
>
> "A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the inven-

> tion was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made."

* * *

Act of July 19, 1952, c. 950, § 1, 66 Stat. 798, USC Title 35, § 112:

> "* * *
>
> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claims shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof."

STATEMENT OF POINTS.

1. The District Court erred in deciding the issue of invention, *i.e.,* obviousness to one of ordinary skill in the art, without consideration of the practical problems confronting the art and the failure of those in the art to learn from the prior art what Svenson disclosed.

2. The District Court erred in reading prior art patents with hindsight to build up verbal response to the various claim elements from a plurality of patents, rather than reading the prior art to determine what it basically disclosed and taught.

3. The District Court erred in treating, as the "teaching" of a prior patent, a single phrase from the description of the prior art pump; in considering a prior art disclosure, the prior device itself, and not the words or particularly just a few of the words used in describing it, is of significance.

SUMMARY OF ARGUMENT.

The claims involved on this appeal are directed to a cam structure for use with rotary blade pumps and serve to accurately control the generally radial movement of the blades. Each claim is limited to a cam which will impart harmonic motion simultaneously to the blades and produce a balanced load on the cam.

The claims were rejected on two principal references, Vickers No. 1,989,900 and Tweedale No. 2,411,602, and a single subsidiary reference, Hawley No. 1,922,951. The two principal references relate generally to the same type of pump in which the Svenson cam is employed. They demonstrate rather than negative, invention in Svenson, because they treat exact configuration of the cam as unimportant so long as it is generally ''elliptical'' or "oval". The subsidiary reference, Hawley, disclosed a pump having unbalanced loads on the cam or rotor. He disclosed and claimed such an unbalanced pump having a cam imparting uniformly accelerated and retardation motion to the vanes. Hawley does not disclose what Svenson shows and claims to be essential, movement of blades in harmonic motion producing a balanced load.

The District Court did not refer to the basic disclosure or teaching of Hawley. Instead the Court relied upon a single phrase in the disclosure. Hawley, like Vickers and Tweedale, did not consider that a precise, accurate cam contour was essential. Although he did prefer a cam which would give uniform acceleration and retardation, he stated that other curves closely approximating such a curve would produce uniform acceleration and retardation.

As an example of an approximation, he mentioned a curve obtained from development of a sine curve. Presumably Hawley contemplated substantially equal latitude in the opposite direction. He thus indicated that what he had in mind could permit a variation of 40% in the amount of radial movement during the first increment of movement, and he contemplated a variation in undesired tangential forces on the order of 30%. Thus his basic teaching was little different from that of Vickers and Tweedale, *i.e.,* that precision in cam contour was not of significance. However, the District Court improperly applied the chance mention of a sine curve as though this were a teaching by Hawley which would make obvious to those in the art that if harmonic motion were produced in a device like Vickers or Tweedale, greatly improved results would follow. In so doing, the District Court imputed to the prior art knowledge which it did not possess and which the cited references did not give it. Indeed, to reach that result the District Court was required to ignore the basic teachings of the prior art.

The Patent Office Board of Appeals further considered Claims 31 and 32 to be improperly functional in calling for cams which would impart harmonic motion simultaneously to the blades. The District Court did not pass upon this question. It is clear that anyone in the art reading the claims would know precisely what the structure should be, how it could be made, and what the limits of the claims are. Moreover, even if the claims were objectionable on this ground under some of the prior decisions, an amendment to the law incorporated in the Patent Codification Act specifically authorizes such claim limitations.

ARGUMENT.

The Structure of Claims 31 and 32 Was Not Obvious to those of Ordinary Skill in the Art.

Claim 31 reads as follows:

> "31. A cam structure for use with rotary blade pumps including translatably mounted blades and comprising a ring-like body having a substantially circular outer surface and having an internal surface including a plurality of cam tracks formed therein, each of said cam tracks being constructed and arranged to impart harmonic motion simultaneously to the translatably mounted blades when relative rotation occurs between the blades and one of the cam tracks and to cause actuation of said blades, the said cam tracks being located diametrically opposite one another causing associated blades to move in harmonic motion outwardly and inwardly, whereby to produce a balanced load on the cam structure."

Claim 32 additionally calls for a plurality of circular surfaces connecting the cam tracks specified in Claim 31. It will be noted that this claim is directed to a cam structure for a rotary blade pump which will accurately control the general radial movement of the blades. The cam will impart harmonic motion simultaneously to the blades and produce a balanced load on the cam. The prior art did not teach this structure. Indeed, the prior art treated exact cam contour as unimportant, while Svenson not only realized that it was important but disclosed the specific cam essential for optimum performance.

The principal references relied upon by the Patent Office and the District Court were Vickers No. 1,989,900

(Joint App. 79a) and Tweedale No. 2,411,602 (Joint App. 87a). These patents relate generally to the type of pump in which the Svenson cam is employed. However, neither disclosed a cam which would impart harmonic motion to the blades. Indeed, neither treated the exact configuration of the cam as of prime importance. Vickers disclosed that it should be generally of "an elliptical shape" and that the movement of the vanes should be a "gradual outward and inward movement" (Joint App. 82a, col. 2, line 55, 83a, col. 1, lines 11 and 12). Tweedale disclosed even less concern for the exact configuration of the cam and movement imparted to the blades by describing the cam merely as "approximately oval" (Joint App. 88a, col. 2, line 18). The disclosure of the two principal references may be summarized as first, relating to the same general type of device; and second, not even recognizing the problem to which the Svenson invention is directed, much less disclosing his solution. It would not be obvious to one skilled in the art from the teaching of Vickers and Tweedale, (*i.e.*, that the exact configuration of the cam was unimportant) that a precise cam configuration was of controlling importance. It was not obvious to Vickers, Inc., assignee of the Tweedale patent, that volumetric efficiency could be improved and that more even distribution of wear over the cam surface could be achieved by use of the Svenson cam (Joint App. 26a, 28a-29a, 71a, 72-a).

The subsidiary reference to which the District Court referred is Hawley No. 1,922,951 (Joint App. 73a). Hawley taught that it was unnecessary to have balanced loads. It will be noted that the Hawley patent discloses a pump having unbalanced loads on the cam or the rotor. However, Hawley did disclose cam configuration in somewhat more detail than Vickers or Tweedale. He taught that the vanes should be moved inwardly and outwardly "with a uniformly accelerated and retarded motion" (Joint App. 76a, col. 1, lines 25 and 26). Hawley repeatedly referred to "uniform acceleration curves" (Joint App. 77a, col. 1, line 61, col. 2, line 82) and disclosed and claimed a structure which would produce "a uniformly accelerated and retardation motion" of the vanes (Joint App. 77a, col. 2, lines 87 and 88 and Joint App. 78a, col. 2, lines 78 and 79).

The District Court did not rely upon or even refer to this basic disclosure of Hawley; nor did the District Court refer to a further disclosure by Hawley that a close approximation of a uniformly accelerated curve was good enough (See Joint App. 77a, col. 2, lines 80-84). Instead, the District Court relied upon a fragment of a sentence.

After having stated in the objects and having disclosed a structure which would provide uniform acceleration and retardation, the Hawley patent states (Joint App. 77a, col. 2, lines 79-90):

> "With the contour of the peripheral wall -C- of the pump chamber connecting the two concentric arcs -A- and -B- constructed in this manner with uniformly accelerated curves or some other forms of curves closely approximating this curve such as obtained from a development of a sine curve, the vanes -18- will be guided smoothly and without shock from one con-

> centric arc to the other with a uniformly accelerated and retardation radial motion starting from rest on one arc and coming to rest on the other arc."

Reading this paragraph as a whole, in the text of the disclosure, it is plain that Hawley taught that uniform acceleration and retardation was his goal but that an approximation was sufficient. He mentioned as an adequate approximation for his desired curve, one "such as obtained from a development of a sine curve". The District Court treated this as a teaching of Hawley that a sine curve which would impart harmonic motion should be used. In so doing, the District Court erred. Although uniform acceleration and deceleration and harmonic motion each provides a gradual acceleration and deceleration, they are different. Simple harmonic motion is the type found in the pendulum of a clock (Joint App. 15a). Uniform acceleration is the type of motion which a body attains after it is dropped (Joint App. 17a). The chart (Pl. Ex. 4, Joint App. 69a) shows that with uniform acceleration, the increments of travel are 1, 4 and 9, whereas with harmonic motion, the increments are 1.2; 4.5 and 9. Thus with harmonic motion there is an increase of 20% during the first increment and an increase of 12½% through the second increment. At the center of the cam profile the curves pass through the same point. However, another chart (Pl. Ex. 5, Joint App. 70a) shows that at this point uniform acceleration will increase the undesired force between cam and blade by approximately 10% and will increase the undesired tangential forces on the blades by 14%. Hawley definitely preferred uniform acceleration but he considered even this as sufficiently unimportant that an approximation would do. Svenson, on the other hand, realized the importance of cam contour in view of the operating conditions encountered. A decrease of 10 to 15% in undesired force creating friction and wear during each of 40 actuations per second is significant.

The District Court's finding that there would be no invention in modifying the cams of Vickers and Tweedale in accordance with the "teachings of the Hawley patent" to provide a plurality of cam tracks to impart harmonic motion simultaneously to the blades is based entirely upon hindsight. One reading the Vickers and Tweedale patents, which indicate that cam contour is not important, and the Hawley patent which states that uniform acceleration and deceleration is the ideal, but an approximation is good enough, would not realize that volumetric efficiency can be increased and wear reduced by employing harmonic motion.

The District Court improperly treated the question of invention as one which could be answered by taking the completed Svenson structure and determining whether various elements of it might have been found in the prior art. In so doing, the District Court completely overlooked the basic teachings of each of the prior art patents relied upon. It is only by ignoring what was taught and advocated by the prior art patents that portions of the Svenson structure can be pieced together from the prior art. A statement of the proper approach to a prior art patent, quoted by the Court of Appeals for the Third Circuit (*Skelly Oil Co.* v. *Universal Oil Co.,* 3 Cir., 31

F. 2d 423, 431) and by this Court (*Becket* v. *Coe,* 69 App. D.C. 51, 98 F. 2d 332, 336) is

> "Would a man who was grappling with the problem solved by the patent attacked, and having no knowledge of that patent, if he had had the alleged anticipation in his mind have said: 'That gives me what I wish?'"

On the facts of the present case, it is plain that none of the three prior art patents would warrant an affirmative answer. Moreover, even if their disclosures are considered together, they do not teach Svenson's structure. It is only by hindsight that his structure was evolved from them by the District Court.

The prior art upon which the District Court relied had been available for some years. The Hawley patent was applied for in 1930 and issued in 1933; the Vickers patent was applied for in 1931 and issued in 1935. Those of ordinary skill in the art had years in which to conceive of Svenson's structure had it been obvious. The fact that they failed to conceive it is strong evidence that it was not obvious. In *L-O-F Glass Fibers Co.* v. *Watson,* .... App. D.C. ...., 228 F. 2d 40, this Court quoted with approval and applied the classic statement of the Supreme Court in *Loom Co.* v. *Higgins,* 105 U.S. 580, 591:

> "* * * it is plain from the evidence, and from the very fact that it was not sooner adopted and used, that it did not, for years, occur in this light to even the most skillful persons. It may have been under their very eyes, they may almost be said to have stumbled over it; but they certainly failed to see it, to estimate its value, and to bring it into notice."

In the same case, this Court quoted and applied the rule from *Expanded Metal Co.* v. *Bradford,* 214 U.S. 366, 381:

> "It may be safely said that if those skilled in the mechanical arts are working in a given field, and have failed, after repeated efforts, to discover a certain new and useful improvement, that he who first makes the discovery has done more than make the obvious improvement would suggest itself to a mechanic skilled in the art, and is entitled to protection as an inventor."

The District Court erred in failing to consider the substance of the disclosures of the prior art patents and in treating the matter as one of mere verbiage. As was pointed out some years ago in *Naylor, et al.* v. *Alsop Process Co.,* 8 Cir., 168 Fed. 911, 917:

> "* * * The patent law, however, has its proper place in the realm of actual industrial life, and not in the limboes of parchment casuistry. The merit of a patent is to be determined, not by its standing in dialectics, but by its actual effects in the art to which it belongs."

In *re Laursen,* C.C.P.A., 73 F. 2d 648, the Court was confronted with prior art patents which had some words which suggested the possibility that it was old to circulate water through a sealed casing while vulcanizing. It was apparent, however, that if such process had been old, the prior art patent was opposed to it. The applicant, regardless of what the prior art teaching may have been, definitely disclosed and claimed the circulation of water.

The Court held this patentable. Likewise, in the present case with the disclosure of Hawley, while Hawley suggests that any movement approximating uniform acceleration might work, Hawley definitely taught that uniform acceleration should be employed in his structure. Hawley likewise taught that there should be unbalanced pressure on the rotor and cam. The Svenson improvement in the balanced type pump should not be denied patentability and condemned as obvious on the basis of the chance inclusion of a single phrase in Hawley's patent. Svenson, like the applicant in the *Laursen* case, departed from the basic teaching of the prior art. See also *Ohio Rake Co.* v. *Bucher & Gibbs Plow Co.,* 6 Cir., 266 Fed. 891.

The District Court relied upon some of the words appearing in the Hawley specification rather than the Hawley pump itself. This was error. While words are necessarily employed in a description, the article described, and not the particular words employed in describing it, is to be considered. Another way of expressing the thought is that a prior art description should not be dissected and a fragment of it treated as the teaching. This is particularly so in an instance such as this, in which the basic idea of the inventor is contrary to what the District Court has found his "teaching" to be. An illustration of this thought appears in *Rumford Chemical Works* v. *New York Baking Powder Co.,* 2 Cir., 134 Fed. 385. The patent there in suit claimed a baking powder in which phosphoric acid was in granular condition, essentially free of pulverulent material. The prior art mentioned "granular" phosphoric acid, but prior art workers thought it essential to reduce the acid to a very fine dust. The patentee secured improved results by having the phosphoric acid largely in granular form. The patent was sustained because the conception and disclosure of the patentee differed from the essential disclosure of the prior art even though there was what might have been termed a literal anticipation.

A close parallel exists between the case at bar and *Graver Tank & Mfg. Co.* v. *Linde Air Products Co.,* 86 F. Supp. 191, affirmed in part and reversed in part, 167 F. 2d 531; affirmed in part and reversed in part, 336 U. S. 271. Claims 18, 20, 22 and 23 of the Jones patent there involved were held valid by the District Court, by the Court of Appeals, and by the Supreme Court. The claims called for a welding flux containing a major proportion of a silicate. A prior art Miller patent stated that instead of preformed manganese silicate, the flux might contain material adapted to react at welding temperatures to produce manganese silicate and stated that this was the preferred form of the invention. The Court distinguished the Jones patent from this because Jones specifically required that the constitutents be prefused and completely reacted. The prior art Miller patent in a sense disclosed the use of a silicate, and it specifically said it might be used, but continued and explained the reason for preferring to have merely the constituents of a silicate. This was held not to anticipate the clear and unequivocal disclosure that all ingredients must be reacted to form silicates prior to welding. The decision of the District Court on this issue was affirmed by unanimous decision of the Court of Appeals of the Seventh

Circuit and again by unanimous decision of the Supreme Court.

The parallel between the *Graver Tank & Mfg. Co. v. Linde* case and the present one is clear. There the prior art Miller patent stated that while the ingredients could be prefused to form a silicate, it was preferred not to pre-fuse them. This was held not to invalidate the Jones patent which clearly and unequivocally stated that the ingredients had to be prefused to form a silicate. In the present case one prior art patent suggests merely that the cam be "elliptical"; another suggests that it be "oval"; and a third, in a different type pump, with unbalanced pressure, preferred uniform acceleration and deceleration but stated that an approximation, such as a sine curve, might do. Svenson, on the other hand, instead of treating the cam contour as a mere matter of preference, and permitting considerable variation in it, clearly and unequivocally specifies a cam which will produce harmonic motion (*i.e.*, a sine curve). Just as Jones specified as important and significant what the prior art considered as not significant and therefore not preferred, likewise Svenson discloses and claims the achievement of harmonic motion as essential while the prior art taught that it was not, and indeed, taught that the particular type of transitional movement was not important. Had the reasoning applied by the Patent Office and the District Court in this case been applied when the Jones patent was in the Patent Office, then patent claims held valid by unanimous decision of the Supreme Court of the United States would never have issued.

Claims 31 and 32 Are Not Improperly Functional.

The Board of Appeals sustained a rejection of Claims 31 and 32 on the ground that the claims failed to include the structure by which the claims must be measured (Joint App. 67a). This has reference to the description of the contour of the cam rise which is limited as "being constructed and arranged to impart harmonic motion simultaneously to the translatably mounted blades".

Claims 31 and 32 are proper for two reasons. First, their statement inherently and necessarily called for definite structure. Harmonic motion is produced by a cam having the configuration of a sine curve. The Svenson specification points this out. The Commissioner brought out on cross-examination that a sine curve is a graphical representation of harmonic motion (Joint App. 27a). The Board of Appeals (Joint App. 56a) and the District Court (Joint App. 93a) both so found. In this instance, since the object following the cam follows a generally circular path, the sine curve is shown in the specification as having been translated from a straight line base to a circular base (See Figs. 2 and 3, Joint App. 47a). A description of the curve as being one which will impart harmonic motion is a very specific and definite one which, when read in the light of the specification, will have clear and definite meaning to anyone in the art.

A second reason that Claims 31 and 32 are not properly subject to attack as being functional is in the provision of the recent Patent Codification Act (Act of July 19, 1952, c. 950, § 1, 66 Stat. 798, USC, Title 35 § 112):

> "* * *
>
> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material or acts in support thereof, and such claims shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof".

This statute authorizes greater liberality in the use of functional expressions than previously permitted, and modifies or renders obsolete some of the earlier decisions as to functional claims (See Commentary by Federico, 35 U.S.C.A. Vol. 1, p. 25). The statute could find no more apt application than to the present case. Anyone reading the patent claims and the specification will know precisely what the structure is, how to construct it, and what the boundaries of the claims are.

CONCLUSION.

Defendant submits that Claims 31 and 32 are allowable. The Patent Office and the District Court recognized that each was new. The history of the art demonstrates that they were not obvious to those skilled in the art. The prior art patents show that the art led away from, rather than toward, Svenson's invention. It is submitted that the judgment of the District Court should be reversed and that the Commissioner of Patents should be authorized to grant Claims 31 and 32 to Svenson.

Respectfully submitted,

Charles L. Sturtevant
813 National Press Building
Washington, D. C.

Roy H. Olson
141 W. Jackson Blvd.
Chicago 4, Illinois

Edward A. Haight
209 South LaSalle St.
Chicago 4, Illinois
Attorneys for Appellant

BRIEF FOR APPELLEE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

APPEAL NO. 13,253

ERNEST J. SVENSON, APPELLANT
v.
ROBERT C. WATSON, COMMISSIONER OF
PATENTS, APPELLEE

APPEAL FROM THE JUDGMENT OF THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF COLUMBIA

CLARENCE W. MOORE,
Solicitor, United States Patent Office,
Attorney for Appellee.

United States Court of Appeals
For the
District of Columbia Circuit
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Joseph W. Stewart
CLERK

Appeal No. 13,253

STATEMENT OF QUESTIONS PRESENTED

In the opinion of appellee, the two questions presented for determination on this appeal are:

1. Upon all the evidence, including the presumption of correctness attaching to the denial by the Patent Office of a patent to appellant, was the District Court clearly in error in finding that the cam structure set forth in claims 31 and 32 on appeal is lacking in invention.

2. May a patent claim, at the very point of novelty, define cam tracks as "being constructed and arranged to impart harmonic motion" in view of a statute authorizing the definition of an element "as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof." (Act of July 19, 1952, c. 950, § 1, 66 Stat. 798, U. S. C., Title 35, § 112).

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APPEAL FROM THE JUDGMENT OF THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF COLUMBIA

BRIEF FOR THE COMMISSIONER OF PATENTS

INTRODUCTION

Ernest J. Svenson, who on January 31, 1946, filed an application for patent entitled "Cam Structure and Method of Manufacture," Serial No. 644,627, appeals (J. A. 98a) as to claims 31 and 32 from the judgment of the District Court (J. A. 97a) dismissing his complaint in an action brought under 35 U. S. C. 145. Claims 31 and 32 define the cam structure. Like the examiner and the Board of Appeals, the District Court found claims 31 and 32 unpatentable over each of the patents to Vickers (J. A. 79a) and Tweedale (J. A. 87a), in view of the patent to Hawley (J. A. 73a).

The judgment dismissing the complaint extended also to claims 11, 12, 13 and 30 of said application, which are drawn to the method of manufacture of the cam structure. No appeal was taken as to these claims.

THE APPLICATION ON APPEAL

The cam structure which is the subject of appealed claims 31 and 32 is shown in Fig. 1 (J. A. 47a) of the drawings of appellant's application and is there designated by the reference numeral 10. It comprises (J. A. 32a, second paragraph) a body 12 having an outer cylindrical surface 14 and an inner cam surface 16. The inner cam surface 16 (J. A. 32a, third paragraph) comprises a pair of circular segments 22, a pair of circular segments 24 of larger diameter than the segments 22, and four cam rise portions 26 interconnecting the segments 22 and 24.

Figs. 2 and 3 (J. A. 47a) of appellant's application indicate how the four cam rise portions are shaped to impart simple harmonic reciprocatory motion to blades 18 of pump rotor 20 (J. A. 47a, Fig. 1). On a circular base line 34a, in the 50 degree arc between points 28 and 30a, there are added the ordinates of the sine curve laid out in Fig 3 (J. A. 32a, final paragraph, to 34a, line 9). The amplitude 32 of this sine curve is equal to the radial distance between the inner cam surface 22 and the outer cam surface 24. The length 34 of the sine curve, corresponding to 180 degrees of the sine curve, is equal to that sector of the line 34a between the points 28 and 30a. The length 34 of the sine curve is divided into fifty divisions. Each ordinate of the sine curve at the fifty division points is added radially to the line 34a at the corresponding divisional point thereon. In the words of appellant's specification (J. A. 33a, only paragraph, fourth sentence), "a shaping is imparted to the cam surface 26 corresponding to the shaping of a sine curve, but corrected to translate the base line for the curve from a straight line to an arc of uniform curvature, corresponding to the path of travel of the rotor 20."

THE REFERENCES

A pump cam is disclosed in each of the patents to Vickers, Tweedale and Hawley.

In the Vickers patent, this pump cam takes the form of the annular liner ring 5 (J. A. 79a and 80a, Figs. 8 and 11; J. A. 82a, second column, line 49, to J. A. 83a, first column, line 14). According to this patentee, the main body 2 of his rotor unit is adapted snugly to fit within that liner ring. The outer surface of this liner specifically is described as circular, and the inner surface as "more of an elliptical shape," whereby to form, it is added, the balanced working chambers 6 and 7. In describing the plurality of cam tracks on the internal surface of his pump cam 5, Vickers states (J. A. 83a, first column, lines 2 to 14):

> The greater part of the surfaces of the liner 5, which define the working chambers 6 and 7, are substantially concentric as are also the diametrically positioned portions 8 of the liner which receive and support the main body of the rotor. The curvature of the intermediate portions between the concentric surfaces just described is gradual and merges with said concentric surfaces with the result that the movement of the

> vanes 4 takes place as a gradual outward and inward movement and at points just prior to and after the development of pressure in the working chambers 6 and 7.

The Tweedale patent, which is assigned to Vickers Incorporated (J. A. 88a, heading), incorporates by reference (*ibid.,* second column, lines 49 to 55) the disclosure of the Vickers patent. The ring member 36 of his patent, Tweedale additionally recites (*ibid.,* second column, lines 16 to 19; J. A. 87a, Fig. 4), has "a cylindrical external shape and an approximately oval internal shape against which the ends of the vanes 34 contact."

For its part, the patent to Hawley (J. A. 73a) shows a rotary pump in which the peripheral wall of the pump chamber 2 has the contour illustrated in Fig. 5 (J. A. 75a). According to Hawley (J. A. 77a, lines 2 to 8), impeller vanes 18 are slidably mounted in slots 17 in rotor 12 "for radial movement of the vanes caused by the outer longitudinal edge of said vanes riding over the irregular contour of the peripheral wall of the pump chamber—2—during the rotation of the rotor—12—."

The surface C, connecting arcs A and B of unequal radii, of the peripheral wall illustrated in Fig. 5 of the Hawley patent, is such that the "vanes—18—will be guided smoothly and without shock from one concentric arc to the other with a uniformly accelerated and retardation radial motion starting from rest on one arc and coming to rest on the other arc" (J. A. 77a, lines 79 to 90; See also, J. A. 76a, lines 10 to 30, and J. A. 77a, lines 44 to 64). The cam profile diagram for such a surface C is shown by dash lines in Plaintiff's Exhibit 4, Chart I (J. A. 69a). Hawley does not, however, limit himself to such surface C. He particularly states (J. A. 77a, lines 84 and 85) that surface C may be constructed with a curve "such as obtained from a development of a sine curve."

SUMMARY OF ARGUMENT

1. Harmonic motion is imparted by a cam surface having the configuration of a sine curve. Such a cam surface is disclosed in the Hawley patent. That patent augments the showing of the Vickers and Tweedale patents and the augmented showing renders claims 31 and 32 unpatentable. Smoothness of operation of pump blades associated with such a cam is indicated in appellant's specification, but Vickers and Hawley earlier provided cams that will smoothly actuate the pump blades. In attaining the smoothness of operation he does, appellant follow the teachings of the Hawley patent. Resolution of the question of invention in the case at bar by a historical approach is precluded by the absence of facts.

2. Under the decision of the Supreme Court in *General Electric Co.* v. *Wabash Appliance Corp.,* 304 U. S. 364, and the decision of this Court in *Application of Ballman et al.,* 57 App. D. C. 146, 18 F. 2d 188, claims 31 and 32 are objectionably functional. Those decisions are not obsolete by reason of Section 112 of the Patent Act of 1952, 35 U. S. C. 112.

ARGUMENT

Patentability

1. While brief, the disclosure in the Hawley patent of a pump cam with a cam surface having the configuration of a sine curve is pointed and plain. The examiner (J. A. 60a and 61a), the Board of Appeals (J. A. 66a), and the District Court (J. A. 95a, Finding of Fact No. 11) so discovered.

Harmonic motion is imparted by a cam surface having the configuration of a sine curve. The examiner (J. A. 58a, third and fourth sentences), the Board of Appeals (J. A. 64a, final sentence), and the District Court (J. A. 93a, Finding of Fact No. 4, third sentence; J. A. 95a, Finding of Fact No. 11, final sentence) so found, appellant's sole witness so admitted (J. A. 27a, final question), and appellant so concedes (Brief for Appellant, page 20, second paragraph).

With the Vickers and Tweedale patents, as principal references, showing a "cam structure for use with rotary blade pumps including translatably mounted blades" that comprises "a ring-like body having a substantially circular outer surface and having an internal surface including a plurality of cam tracks formed therein" and with the Hawley patent, as a subsidiary reference, showing a plurality of cam tracks each "constructed and arranged to impart harmonic motion simultaneously to * * * translatably mounted blades when relative rotation occurs between the blades and one of the cam tracks and to cause actuation of said blades," and additionally showing those cam tracks as "joined by a plurality of circular surfaces," appellant's claims 31 and 32 are met by and unpatentable over the cited prior act. The examiner (J. A. 60a), the Board of Appeals (J. A. 66a) and the District Court (J. A. 95a and 96a, Findings of Fact Nos. 12, 13, and 14) so ruled.

Appellant's specification is to be consulted for the purported advantages of his claimed cam structure (*Abbott et al.* v. *Coe,* 71 App. D. C. 195, 109 F. 2d 449). In his specification (J. A. 33a, final sentence), appellant indicates that his cam surfaces or tracks 26 are shaped to impart harmonic motion to insure "a maximum smoothness of operation" of his pump blades 18. Smoothness, however, is desired and obtained with the vanes or blades 4 in the Vickers rotor by shaping of cam surfaces. Vickers, in the section of his patent already quoted (J. A. 83a, first column, lines 7 to 14), recites that the curvature of the intermediate portions between the concentric surfaces "is gradual and merges with said concentric surfaces" so that "the movement of the vanes 4 takes place as a gradual outward and inward movement." Smoothness of operation of his vanes 18 further is sought and gained by Hawley. With respect to the construction of the contour of his peripheral wall C with uniformly accelerated curves, Hawley teaches (J. A. 77a, lines 79 to 90; see also J. A. 76a, lines 16 to 29) that "the vanes—18—will be guided smoothly and without shock from one concentric arc to the other." Under the same teachings of the Hawley patent, a "curve such as obtained from a development of a sine curve" is made alternative to and equivalent of a uniformly accelerated curve.

To the extent that appellant attains "maximum smoothness" of operation of his blades 18 and "optimum performance" (see Brief for Appellant, page 10, second paragraph), he follows the prior art teachings of the Hawley patent. In every other aspect, including a balanced load, his claimed cam structure is borrowed from the showings of the patents to Vickers and Tweedale. Appellant may have provided a better cam structure. He did so, however, only by combining, in an obvious manner, desirable features of the three cited patents. What the Court of Customs and Patent Appeals said in *In re Smith,* 34 C. C. P. A. 1007, 161 F. 2d 274, applies here. In that case, the Court stated:

> Surely it cannot be urged that because appellant has picked out of the art certain well-known features with well-known functions and combined them into a new structure, with possible improved results, this necessarily connotes invention. Assuming that appellant has achieved improved results and that his structure has advantages over anything produced in the prior art, this does not necessarily signify that his production required the exercise of the inventive faculty. The old elements all perform the same functions in the new combination that they performed in the prior art; there is no new or unexpected coaction between them, and the results obtained can hardly be said to be those which are unobvious or unexpected.

The historical approach, which appellant seemingly invites, may be a happy approach in resolving the vexing question of invention. Courts, however, are powerless to adopt such an approach if the facts of history are not deevloped for them in the proofs. Such is the situation in the case at bar. This Court does not know, and cannot know, whether a "problem had existed for some years" (Question 1 of Appellant's Statement of Questions Presented). It does not know, and cannot know, whether persons having ordinary skill in the art, "failed, after repeated efforts," to discover a solution (see *Expanded Metal Co.* v. *Bradford,* 214 U. S. 366, 381, as quoted in the Brief for Appellant, page 16). It does not know, and cannot know, "the length of time the art, though needing the invention, went without it: the number of those who sought to meet the need and the period over which their efforts were spread: how many, if any, came upon it at about the same time, whether before or after: and—perhaps most important of all—the extent to which it superseded what had gone before" (Judge Learned Hand in *Safety Car Heating & Lighting Co.,* v. *General Electric Co.,* 155 F. 2d 937, 939. Here there substantially is no more than the age of the references, which, in itself, is of little significance, *In re Rosenberger,* 28 C. C. P. A. 818, 825; 116 F. 2d 507, 511, and testimony, to which appellee properly objected (J. A. 26a), of *ex parte* tests comparing pumps embodying the cam structure in issue with "Vickers pumps" of undisclosed structure.

Functionality

2. The Board of Appeals (J. A. 67a), following the examiner (J. A. 61a), found claims 31 and 32 on appeal to be functional under the doctrine of *General*

Electric Co. v. *Wabash Appliance Corp.,* 304 U. S. 364, as attempting to define over the Vickers and Tweedale references at the very point of alleged novelty, by a bare statement of function. The District Court expressed no opinion on this matter (J. A. 91a; J. A. 96a, Finding of Fact No. 15).

In line with the cited decision of the Supreme Court and likewise directly in point in the case at bar is the earlier decision of the Court of Appeals of the District of Columbia in *Application of Ballman et al.,* 57 App. D. C. 146, 18 F. 2d 188, affirming the decision of the First Assistant Commissioner of Patents in *Ex parte Ballman and Evers,* 1927 C. D. 51.

Appellant, in effect, urges (Brief for Appellant, pages 20 and 21) that the law of the foregoing cases is now obsolete in view of the last paragraph of 35 U. S. C. (1952) 112. The Court of Customs and Patent Appeals, however, expressly held to the contrary in *In re Arbeit et al.,* 41 C. C. P. A. 719, 206 F. 2d 947. With referene, *inter alia,* to the decision of the Supreme Court in the *General Electric* v. *Wabash* case, the Court of Customs and Patent Appeals said:

> The foregoing decisions, of course, were rendered before the Patent Act of 1952 was enacted. We think it is perfectly clear that under them and a long line of similar decisions, none of the appealed claims before us, except numbers 31 and 33, properly could have been allowed prior to the passage of that Act, and so, we come to the ultimate question of whether that Act has altered the patent law so that the purely functional limitations in claims 1, 37 (with its dependent claim 38), and 43 (with its de-

pendent claims 44, 45, and 46), may be taken as meeting the statutory requirements of definiteness.

The only changes in phraseology necessary to be considered in connection with that question are those found in the last paragraph of Sec. 112, *supra.* It seems obvious to us that a construction of that paragraph, such as appellant contends for, would render it wholly inconsistent with the first and second paragraphs which, like former R. S. 4888, are explicit and *mandatory* in requiring a written description expressed in "full, clear, concise and exact terms" *in the specification,* and so set forth *in the claims.* In the instant case, the descriptions given in appellant's specification are no more definite than the functional statements in the claims, and the latter are not sufficient to meet the requirements of the Act.

It is unnecessary for us to attempt a complete construction of Section 112, *supra,* at this time. It is sufficient to say that, in our opinion, it has no application to the facts of this case.

CONCLUSION

For the reasons given in the statement of the examiner, in the decision of the Board of Appeals, in the decision of the District Court, and in this brief, appellant, it is submitted, is not entitled to a patent containing either of claims 31 and 32 on appeal.

CLARENCE W. MOORE,
Solicitor, U. S. Patent Office,
Attorney for Appellee.

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REPLY BRIEF FOR APPELLANT.

IN THE

UNITED STATES COURT OF APPEALS

FOR THE DISTRICT OF COLUMBIA

United States Court of Appeals
For the
District of Columbia Circuit
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Appeal No. 13,253

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Appellant,

vs.

ROBERT C. WATSON, Commissioner of Patents,
Appellee.

Appeal from the United States District
Court for the District of Columbia

CHARLES L. STURTEVANT
813 National Press Building
Washington, D. C.

ROY H. OLSON
141 W. Jackson Blvd.
Chicago 4, Illinois

EDWARD A. HAIGHT
209 South LaSalle St.
Chicago 4, Illinois
Attorneys for Appellant

The Scheffer Press, Inc.—ANdover 3-6850

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The Structure of Claims 31 and 32 Was Not Obvious to Those of Ordinary Skill in the Art.

(Brief for Appellee, pp. 6-9)

The Brief for Appellee repeats, rather than supports, the very errors upon which this appeal is based. Of the three points set forth by Appellant (Brief, p. 7), the Appellee discusses only the first.

The Appellee (Brief, pp. 8-9) argues that Appellant's first point (that the District Court erred in failing to consider the practical problems confronting the art and the failure of the art to find Svenson's answer) is unsound for want of additional proof. Inherent in this argument is the concession that if there were problems confronting the art, which the art failed to solve and which Svenson did solve, Svenson did more than was obvious to the art. When the Appellee states that the facts are not shown in the record, Appellee would disregard the testimony of Appellant's witness Olson (Joint App. 8a). The qualifications of the witness have not been challenged and his testimony with the other evidence in the case shows that Svenson's invention was not obvious.

The problems of wear, vibration, hammering of blades and loss of seal between blades and cam exist (Brief for Appellant, pp. 3-4). They necessarily have existed as long as pumps of this general type have been known—since 1931 at least (Joint App. 82a). Svenson made a substantial improvement and the John S. Barnes Corporation has manufactured and sold many pumps having that improvement (See Brief for Appellant, pp. 5-6). The very fact that others failed, for years, to conceive the Svenson structure, shows that it was not obvious (See Brief for Appellant, p. 15).

The Appellee (Brief, p. 9) quotes from the opinion of Judge Learned Hand in *Safety Car Heating & Lighting Co.* v. *General Electric Co.,* 2 Cir., 155 F. (2d) 937, 939. Factors which might be considered in determining the question of obviousness are there mentioned. The opinion as a whole shows that they are not the only factors, nor are they all essential factors, as suggested by Appellee. They were factors on which evidence was available in the case.*

The Appellee asserts that the age of the reference is of little significance in showing the length of time that the art may have been confronted with a problem (Brief for Appellee, p. 9). The cited case, *In re Rosenberger,* 28 C.C.P.A. 818, 825, 116 F. 2d 507, 511 does not support Appellee. The Court there said that "the mere fact alone that the reference is old does not prevent it from being properly used as a reference if the structure disclosed and relied upon is clearly and definitely shown". Appellant does not urge that the prior art should not be considered because it is old. Appellant's point is that the age of the reference shows that the type of pump in which the problems solved by Svenson were involved, was old. Moreover, as pointed out hereinafter, the structure disclosed in the reference "must be clearly and definitely shown". Here the Appellee has failed to produce references which, even in combination, clearly and definitely show the Svenson invention.

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*We note that this decision, upon which the Appellee principally relies, was decided during the era "when the test of invention has become increasingly so severe" (155 F. 2d 940). The same Court, in an opinion also written by Judge Learned Hand has found that Congress has restored the original, liberal attitude towards inventors and rejected the strictness of some decisions of the 1930's and 1940's (**Lyon v. Bausch & Lomb Optical Co.**, 2 Cir., 224 Fed. (2) 530, certiorari denied 350 U.S. 911, reh. den. 350 U.S. 955).

The Appellee (Brief, p. 9) objects to comparisons made in the record between pumps employing the Svenson invention and the commercial pumps produced by the assignee of the Vickers and Tweedale references. Appellee suggests that the cams of the Vickers pumps are "of undisclosed structure." It is true that the record does not show what their precise cam contour is. However, whatever it may be, it is not the contour of the Svenson cam. The Vickers and Tweedale disclosures did not teach the Svenson invention to the company to which they were assigned, nor did they teach cams having the even wear pattern and the efficiency of the Svenson cams (Joint App. 28a, 29a, 71a, 72a).

The second point of Appellant (that the District Court erred in reconstructing the prior art by hindsight) is not answered by Appellee. Instead, the Appellee (Brief, pp. 7-8) adopts the same approach. The Appellee has not shown that the prior art taught anything that obviously would lead to the Svenson invention. Instead, the Appellee has started with the Svenson invention and purported to find antecedents for its elements. The case of *In Re Smith,* 34 C.C.P.A. 1007, 161 F. (2) 274, 278, upon which Appellee relies (Brief, p. 8) is not authority for such an approach. The last sentence quoted by Appellee pointed out that on the facts of that case there were no unobvious or unexpected results. In the paragraph following that quoted by Appellee the Court said:

> "Of course, it is well-settled law that if one selects from the prior art well-known features in such a manner as to produce new, unobvious, unexpected and useful results which are not merely the accumulations of the good results taught by the art he has made an invention. Frequently combinations of old elements in new structures have resulted in inventions of a high order".

Are there unexpected results in the present case, or are there just the accumulations of the results of Vickers, Tweedale and Hawley? Would one skilled in the art prior to Svenson, having the three references before him, have considered it obvious to use the type of pump of Vickers or Tweedale—not of Hawley—and modify it by employing a cam to impart harmonic motion to the vanes—not the cam of Vickers or Tweedale, or even of Hawley? Would it have been obvious to the one skilled in the art that to do this would increase efficiency, and result in even wear over the cam surface? The Appellant submits that there is nothing in the three references which suggests that to thus do what they do not teach would produce the new and improved results.

Appellant's third point (that the District Court erred in considering a single phrase of Hawley, rather than the Hawley teaching as a whole) is not answered by Appellee. Again the Appellee merely repeats the error of the Patent Office and the District Court. Thus the Appellee (Brief, p. 5) asserts that Hawley "particularly states (J.A. 77a, lines 84 and 85) that surface C may be constructed with a curve 'such as obtained from a development of a sine curve' ". This is scarcely more accurate than the Examiner's statement (Joint App. 60a), "Hawley expressly states that he uses a curve that is 'obtained from a development of a sine curve' ", or the statement in Finding 11 of the District Court (Joint App. 95a) that "Hawley particularly states that each surface C may, in one instance, be constructed with a curve such as obtained from a development of a sine curve". In each instance a few words are extracted from the Hawley specification in view of, and because of, what Svenson taught, without in any instance considering the Hawley disclosure itself.

The Hawley patent (Joint App. 73a-78a) should be read to determine what it would teach one skilled in the art prior to Svenson. What was Hawley's idea? What did he "teach" was significant? What he taught was that one should use an unbalanced pump, not a balanced one; that during the radial movement of the vanes at the inlet and outlet of the pump, the pressure should be equal on both sides of each vane, and that the vanes should move inwardly and outwardly with uniform acceleration and retardation. In passing, he mentioned that movement of the vanes did not have to be accomplished with precise uniform acceleration and deceleration. Something "closely approximating" this would be enough. He mentioned a curve, such as obtained from a development of a sine curve, as an example of an approximation. During travel past the first one-sixth and last one-sixth portions of the cam surface in question, a vane will move radially 20% more with simple harmonic motion than with uniform acceleration and retardation. (Joint App. 17a, 69a) Presumably, Hawley intended a similar close approximation in the other direction permitting an overall variation of 40% in extent of cam travel. If this is a definite teaching of anything, it is a teaching that precision is not required. The use of harmonic motion, rather than uniform acceleration and deceleration, reduces the force on the cam and wear by nearly 10%, and reduces the circumferential force which tends to lock the blades in their slots by more than 14%. (Joint App. 18a-19a) Hawley did not appreciate this, teach it, or avail himself of it. In the unbalanced pump which he disclosed, perhaps he considered it immaterial. Perhaps, as he states, an approximation of uniform acceleration and deceleration is adequate in that pump. Our point is that in his chance mentioning of what he considered an approximation of uniform acceleration and deceleration, Hawley did not make it obvious to one skilled in the art that the general pump of Vickers and Tweedale, not of Hawley, should be used; that the cams of Vickers and Tweedale should not be used; that the cam of Hawley should not be used; but that a new cam should be employed having rise portions corresponding to those mentioned, by chance, but not preferred by Hawley.

Claims 31 and 32 Are Not Improperly Functional.

(Brief for Appellee, pp. 9-11)

The Appellee urges that Claims 31 and 32 were soundly rejected as improperly functional. The District Court did not decide the question. The Appellee assumes that the claims would not have been allowable under the law as stated in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, and assumes that the only issue is whether the new provisions in the recent Patent Codification Act (Act of July 19, 1952, c. 950, Sec. 1, 66 Stat. 798, USC, Title 35, Sec. 112), providing that an element may be expressed as a means or step for performing a specified function without recital of structure, has changed the law. Appellee urges there was no change.

The Appellee errs in its assumption that the claims are not allowable under the law as stated in the *General Electric* case. In that case, the claims on a filament for an electric lamp defined the tungsten as "of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp or other device". The specification in that case nowhere described the filament itself in any more specific terms. The specification did disclose a process for making the particular type of large grains which the inventor had in mind but neither the specification nor claim described the product itself save in functional language. It was on this state of facts that the Court commented on "conveniently functional language at the exact point of novelty". The Court pointed out that a limited use of terms of effect or result, accurately defining the essential qualities of a product to one skilled in the art, may be permissible or even desirable. On the facts of that case, however, the Court expressed doubt whether the claim language conveyed definite meaning to those skilled in the art. That was its vice. Moreover, the claims were drawn to an improved single element (a lamp filament) whose only novelty lay in its composition, while the Svenson claims are drawn to a new combination of elements.

Following the *General Electric* decision, the Supreme Court sustained a claim on a dry cell, including a sheet metal sheath "enclosing the side walls of said metal electrode and tightly embracing said closures so as to prevent leakage of the electrolyte from the unit" (*Goodyear* v. *Ray-O-Vac Co.,* 321 U. S. 275). This was functional language in a sense, but it had to do with the relationship of the structural elements. The claim was held valid even though the prevention of leakage was the very heart of the invention.

There are other examples of seemingly functional language allowed by the Patent Office and sustained by the Courts since the *General Electric* case. For example, *Minnesota Mining & Manufacturing Co.* v. *International Plastic Corp.,* 7 Cir., 159 F. 2d 554, 559, in which claims contained limitations such as

> "the adhesive and backing being of such kinds that the back surface of the backing is inactive to the adhesive coating to a degree permitting unwinding of the adhesive sheet from rolls thereof without delamination or offsetting of adhesive"

were sustained. The Court pointed out that such words were words of limitation, which expressed the relationship of the structural elements.

Another example is a claim on a control system for an automatic elevator, sustained in *City of Grafton* v. *Otis Elevator Co.,* 4 Cir., 166 F. (2d) 816, 819. The opinion shows that it had previously been sustained by the Second Circuit, and certiorari denied. The specification was most detailed and specific as to the structure and accordingly the claim, including the following limitations, was sustained:

> "means operable in response to each of said switches to register a call for the floor at which the switch is located; means responsive to the first call registered to initiate starting of the car; mechanism controlled by car movement and operable to intercept the car when moving upwardly at the floors for which up calls have been registered and when moving downwardly at the floors for which down calls have been registered, said starting means acting to initiate restarting of the car after each stop so long as calls which have been registered remain unresponded to; and means operable when each call is answered to cancel that call."

Moreover, the recent Patent Codification Act, as pointed out in the Brief for Appellant, pages 20-21, contains express authorization for claims calling for means for performing a specified function without recital of structure, with the provision that such claims shall be construed to cover the disclosed structure and equivalents. The Appellee urges (Brief, pp. 10-11) that although this provision was new, and is clear and unambiguous, it in no way changed the law. The only authority cited by Appellee on this point, *In Re Arbeit, et al.,* 41 CCPA 719, 206 F. (2d) 947, contains some *dicta* which at first glance appears to be in accord with Appellee's position. However, as the Court pointed out in that case, neither the specification nor the claims contains anything more definite than the functional statements. The Court held that the new section of the Act had no application to the facts of that case.

Claims 31 and 32, in calling for cam tracks "being constructed and arranged to impart harmonic motion", are most specific and cannot be misunderstood by anyone skilled in the art. As the Appellee points out (Brief, p. 6), harmonic motion is imparted by a cam surface having the configuration of a sine curve; the Examiner, the Board of Appeals, the District Court, the Appellee and Appellant are all agreed; so is one skilled in the art (Joint App. 27a). It is to be observed that although the Appellee would have the Court apply the doctrine of the *General Electric* v. *Wabash* case, the Appellee does not point out how Claims 31 and 32 embody any of the vices of the *General Electric* claim. They do not.

Respectfully submitted,

Charles L. Sturtevant
813 National Press Building
Washington, D. C.

Roy H. Olson
141 W. Jackson Blvd.
Chicago 4, Illinois

Edward A. Haight
209 South LaSalle St.
Chicago 4, Illinois
Attorneys for Appellant